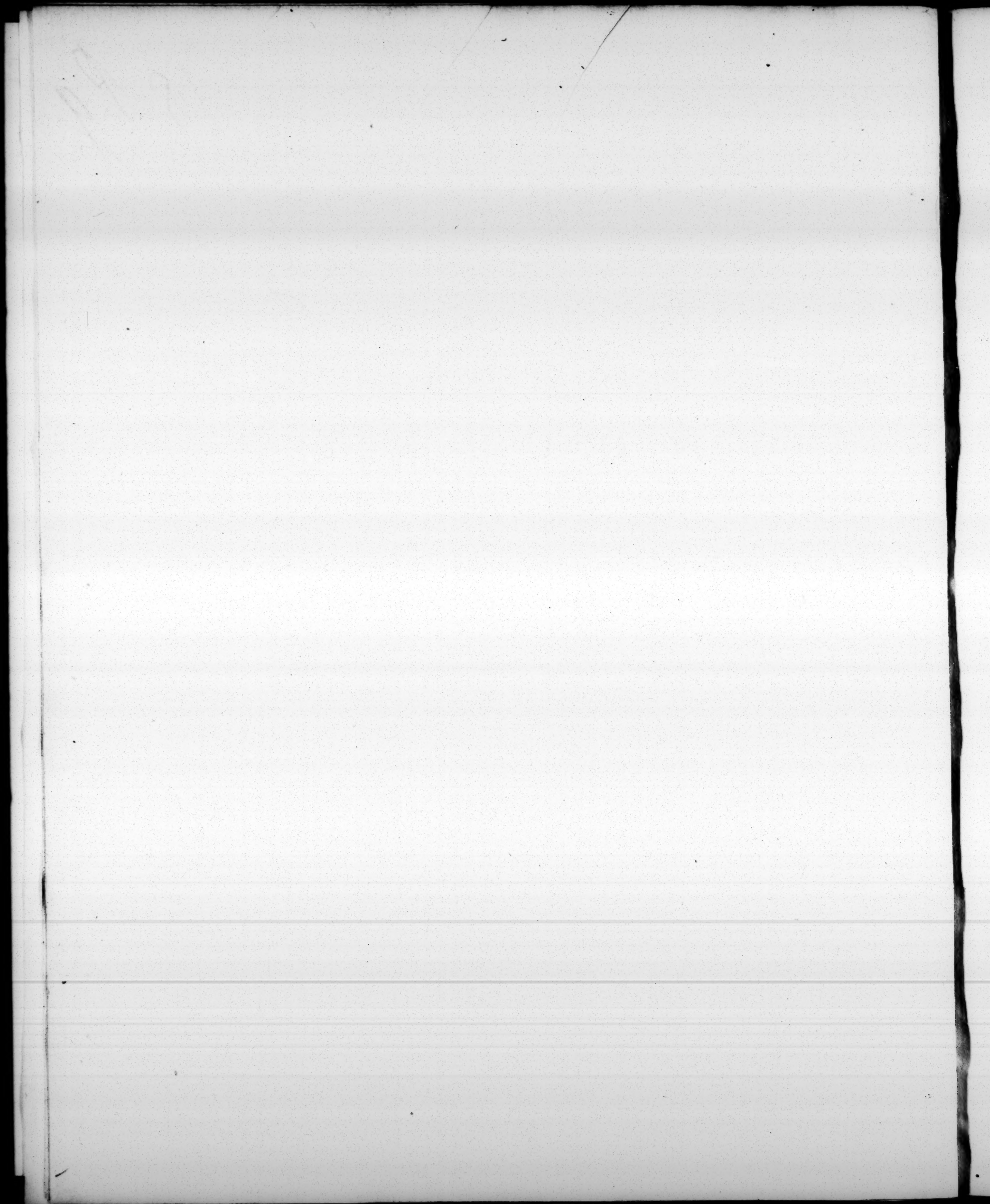


AN
INQUIRY
INTO THE
CAUSE OF MOTION.



18 Pg.

AN
I N Q U I R Y
I N T O T H E
C A U S E O F M O T I O N ;

O R,
A GENERAL THEORY OF PHYSICS,
GROUNDED UPON THE PRIMARY QUALITIES OF MATTER.

ILLUSTRATED WITH COPPER-PLATES.

B Y S. M I L L E R. 50.

L O N D O N :

PRINTED FOR THE AUTHOR, BY C. ETHERINGTON, FLEET-STREET.

M.DCC.LXXXI.

Jos: Banks

INTRODUCTION.

THE Author of the ensuing sheets, with the utmost diffidence, submits them to the perusal of the public. Innumerable objections may undoubtedly be raised in a subject of such great magnitude, he thinks too justly to imagine he can be always right; but he cannot help flattering himself some general good may be drawn from the hints to be found in the present work.

THE mind of the man who solicits the public to countenance his labours, must be more or less agitated as he feels himself unequal or superior to the subject upon which accident or inclination may have led him to expatiate. If a name already high in the literary world, if acknowledged superior abilities, or anterior publications, have marked an author as the proper object of public deference and respect, there is little doubt but the product of his pen will meet with that reception which its merit deserves,

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and a liberal-minded age can bestow. But when an individual, obscure in his connexions, unknown amongst the list of great names, without even the aid of an academical education, presumingly obtrudes himself to the notice of the public, and that too upon a topic which has engaged the attention and been adorned by the learning and penetration of the greatest geniusses in every age, he may at once expect to be ranked amongst madmen and enthusiasts, and consigned to that oblivion which his temerity seems so justly to merit.

It is peculiarly the business of philosophy to raise the mind above those narrow prejudices by which the generality of mankind are actuated; encouraged by this idea, and the enlightened disposition of the age, I look for a more favourable reception than men under similar circumstances have formerly received. It is a disagreeable task to controvert old established opinions, errors become sanctified by long prescription, putting on the appearance and usurping the place of truth so strongly, that we will not believe we have been deceived; this, however, experience evinces, is not unfrequently the case: many positions, which our ancestors considered as orthodox and incontrovertible, have been found utterly unworthy the place they had obtained. Every object is now canvassed with the eyes of reason and philosophy; so many errors have been detected, some men are induced

to suspect the very existence of truth, and give up the pursuit as groundless; let not this, however, abate the ardor of our researches. It may be said the works of our philosophers bear evident marks of that finished artist, who unfortunately in his copy missed the outlines of the face.

THE generality of philosophers have considered all matter as passive and inert, and that whatever motion it is possessed of was communicated by the DEITY at the time of its creation. According to DES CARTES, " GOD created matter of an indefinite extension, he then divided this matter into little square portions or masses full of angles, and impressed two motions on this matter; one, whereby each part revolved round its center; another, whereby an assemblage or system of them turned round a common center: whence arose as many different vortices or eddies as there were different masses of matter thus moving round common centers."—Sir ISAAC NEWTON, observing this hypothesis of vortices pressed with many difficulties, proposed a system wherein these difficulties should be removed. Accordingly he supposes that GOD formed matter into those large spherical masses in which it is now found; that every particle in these various masses was impressed with a strong passion or desire, by virtue whereof they would constantly endeavour to unite with the particles of the other masses; then considering the celestial space as void,

these bodies were variously disposed, and such motions communicated as should just serve to counteract the propension of uniting, by which means a perfect harmony and due equilibrium is preserved throughout the whole.

A MAN who, without any other aid than the strength of his own mind, could raise a system which at first sight furnishes so beautiful and perfect a view, has certainly the highest claim to our admiration and regard; this, however, should not deter us from examining whether even such abilities may not have been deceived: the system minutely investigated will not prove a true copy of nature; on the contrary, it will be discovered, from a thousand instances, these properties (the existence whereof ought to have been first proved) upon which the very being of the system necessarily depends, are no where to be found.

I WOULD by no means impress my reader with a notion that the defectiveness of the Newtonian philosophy is any new discovery, many have been its opponents, numerous its advocates, of the former I must profess myself one; with how much reason, those who choose to favour me with their attention must determine.

THE Theory (if the rude sketches which are combined almost without order or regularity in the following pages are worthy to
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be so called) is the result of a thorough conviction, grounded upon experiment and the obvious appearances of nature, that the general opinion of *Attraction* was ill-founded and absurd; the more I examined the more forcibly this conviction pressed upon my senses, and encouraged, to a stricter scrutiny. The next step was natural; if not from *Attraction*, how then are the various phenomena of the universe produced?—Chance led me to adopt the idea upon which the theory is grounded; that matter must be distinct, of different properties, and not alike *homogeneously sluggish and inert, indifferent either to rest or motion*.—Possessed with this opinion, I again had recourse to experiments, and reconsidered the objects around me; the path which was before intricate, perplexed, and filled with so many obstacles, seemed now divest of these difficulties, appearing smooth and perfect; the various operations of nature no longer appeared inexplicable or contradictory, but each seemed to spring as a necessary consequence of these primary laws.

LET it not be thought that I consider myself as entitled to demand the attention of the philosophic world; I am fully aware how trifling my claim to the notice of men who possess so many superior advantages; did not experience declare how often important objects have been attained by means apparently as inadequate to the accomplishment of such effects as this crude production of my pen,
I would

I would never have dared to obtrude my opinions upon the public ; but satisfied with the purity of my views, and the justness of my wishes, I submit myself to their encouragement, or censure as their liberal judgments (taking in the whole circumstances of the case) shall think meet to award.

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ERRATA.

- Page 36, l. 14, for that is the distance, read that is *at* the distance.
38, l. 10, for The figure, r. *figure the 1st*.
59, l. 6, for sun's, r. *moon's*
70, l. 19, for C, r. *c*.
84, l. 11, for lodged in particles, r. lodged in *the* particles.
97, l. 12, for must arise in quantities, r. must arise in *the* quantities.
99, l. 11, for longer, r. *larger*.
127, l. 6, for his, r. *he*.—Ibid. l. 7, dele *be*.
127, bottom l. for conformation, r. *confirmation*.
131, l. 19, for increafe, r. *increases*.
138, l. 18, for would had, r. would *have* had.
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AN
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THE opinions of the ancients respecting the phenomena of motion are of little consequence; their knowledge in subjects of this sort, being entirely vague and hypothetical, can be of no use to us in the present inquiry.

THE Cartesian hypothesis is certainly very ingenious; and although it falls short of accounting for the appearances of nature, yet as DES CARTES, by introducing geometry into physics, has taught us a more certain method of reasoning, we are undoubtedly under material obligation to this great man.

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THE Newtonian philosophy is a still more ingenious system, wherein we trace much depth of thought and acuteness of reasoning; but even this theory is not without its objections, for we cannot conceive how the heavenly bodies act upon each other; that is, how the sun *attracts* the earth and the planets, or the earth the moon, &c. True philosophy admits of no action but what is performed by immediate *contact* and impulsion; of this Sir ISAAC NEWTON was sensible, for he says, he does not consider attraction and gravity as causes, but as effects, produced by some unknown agent; and to convince us of this, he has given a query at the end of his Book of Optics, which runs thus: “ Is. “ not this medium much rarer within the dense bodies of the sun, “ stars, planets and comets, than in the empty celestial spaces between them? And in passing from them to greater distances, “ doth it not grow denser and denser perpetually, and thereby “ cause the gravity of those great bodies towards one another, and “ of their parts towards the bodies; every body endeavouring to “ go from the denser parts of the medium towards the rarer? For “ if this medium be rarer within the sun’s body than at its surface, “ and rarer there than at the hundredth part of an inch from its “ body, and rarer there than at the fiftieth part of an inch from its “ body, and rarer there than at the orb of *saturn*; I see no reason “ why the increase of density should stop any where, and not rather “ be continued through all distances from the sun to *saturn*, and “ beyond.

“ beyond. And though this increase of density may at great
“ distances be exceeding flow, yet, if the elastic force of this me-
“ dium be exceeding great, it may suffice to impel bodies from the
“ denser parts of the medium to the rarer, with all that power
“ which we call gravity. And that the elastic force of this medium
“ is exceeding great, may be gathered from the swiftness of its vi-
“ brations.” He proceeds to prove these vibrations must be swifter
than light, to admit the alternate fits of easy transmission and easy
reflection.

SIR ISAAC proposes the above merely as an hypothesis to be fur-
ther investigated; some late authors have taken up the idea, but
without turning it to any material advantage; the doctrine does
not seem very conformable to the simplicity of nature: it is not
easy to conceive how the equilibrium of the power is preserved,
nor, if there be any diminution, whence, or how, the deficiency
is supplied; and further, if by this power the planets are prevented
from flying off from their center, of what consequence is the bulk,
&c. of the central body? and it is no less difficult to understand,
how any subtle matter is capable of acting on the internal parts
of a body, so as to produce an effect in proportion to its quantity
of matter.

BUT, admitting the hypothesis to be true, we are still as far
from the main object of our researches; for without having re-

course to an agent, bodies would still remain at rest; so that no light is hereby thrown upon the philosophy of motion, but rather more difficulties are added to the subject; since if this medium be so much denser on the sides of bodies the furthest from the sun, as to impel them towards it with that power which is called the attraction of gravity, the medium cannot be conceived so rare but it must impede their annular motion, and of course we must suppose an agent acting continually on the bodies of the planets, to preserve that uniformity which is found between their velocities now, and formerly.

THE general principles of this philosophy are founded upon the evident phenomena and motions of the heavenly bodies, (viz.)

THE SUN is placed in the center of the system, and revolves upon his axis in 25 days, 6 hours.

MERCURY revolves round the sun in 87 days, 23 hours; it is not known whether this planet turns upon his axis, no spots being perceptible on his surface, and the nearness of his orbit to the sun prevents frequent observations: in Mr. FERGUSON'S tables (from which all these numbers are taken) the distance of mercury from the sun is 36.841.468 miles.

VENUS

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VENUS revolves round the sun in 224 days, 17 hours, and turns upon her axis according to some in 24 days, 8 hours, and according to others in about 23 hours; the distance of her orbit 68.891.468 miles.

THE EARTH *with the moon*, revolves round the sun in 365 days, 6 hours nearly, and turns upon its axis in 24 hours, distant from the center 95.173.000 miles: the moon revolves round the earth in 27 days, 7 hours, and 43 minutes, and turns upon her axis in precisely the same time; the distance of her orbit from the center of the earth 240.000 miles.

MARS completes a circuit round the sun in 686 days, 23 hours, and turns upon his axis in 24 hours, 40 minutes: the distance of his orbit about 145.000.000 miles.

JUPITER, *with his four satellites*, completes a circuit round the sun, at the distance of 494.990.976 miles in 4332 days, 12 hours, and revolves upon his axis in 9 hours, 56 minutes. The nearest satellite revolves round him in 1 day, 18 hours, 36 minutes; the second in 3 days, 13 hours, 15 minutes; the third in 7 days, 3 hours, 59 minutes; and the fourth in 16 days, 18 hours, 30 minutes; the distances of their orbits respectively are 229.000, 364.000, 580.000 and 1000.000 miles.

SATURN,

SATURN, *with his five satellites and ring*, revolves round the center in 10.759 days, 7 hours, at the distance of about 907.956.130 miles: no spots are perceptible on the surface of this planet, and therefore astronomers have not been able to ascertain the period of his diurnal rotation. The orbit of the nearest satellite is distant 140.000 miles, and performs a revolution in 1 day, 21 hours, 19 minutes; the second at the distance of 187.000 miles in 2 days, 17 hours, 40 minutes; the third, at the distance of 363.000 miles, in 4 days, 12 hours, 25 minutes; the fourth, at the distance of 600.000 miles in 15 days, 22 hours, 41 minutes; and the fifth, at the distance of 1.800.000 miles, completes a circuit in 79 days, 7 hours, and 48 minutes. Writers speak differently of the thin broad ring which surrounds this planet, some say it is inclined 31 degrees, and others, that it is parallel to the ecliptic: it is supposed to be 21.000 miles in breadth, and about the same distance from the body of saturn.

COMETS move in long ellipses, and in every direction; it has been asserted there are at least two or three-and-twenty belonging to our system.

FROM the above, and various other manifest effects, these general principles are deduced; That the sun is a body of fire, placed nearly in the center, communicating light and heat to the whole

whole system ; that the planets revolve round him, and persevere in their orbits, by what is called the *attraction of gravity*, or a due equipoise of the centripetal and centrifugal forces, describing equal areas in equal times. And to account for the origin and continuance of the motions of the heavenly bodies, it is supposed the planets were projected by the arm of the Creator, and that they move in perfectly free and open space ; upon these principles, according to the Newtonians, all the phenomena of the celestial bodies are explained.

BUT light, or heat, which is the same thing, it is very evident comes from the sun with an inconceivable progressive rapidity, and a great variety of experiments clearly shew it is material, particularly that of collecting the rays by a mirror, when they are found to act precisely the same as fire, expanding and repelling all bodies: now if these rays be fire, and fire acts uniformly the same, expanding and repelling all substances whatever, it may reasonably be presumed these effects are produced by the action of the sun upon the bodies and atmospheres of the planets ; and therefore (if these premises are just) instead of supposing the sun is endued with an attractive quality, it is far more reasonable to assert his property is diametrically opposite to that of attraction.

ANOTHER

ANOTHER deduction is, that the celestial space must be a perfect void; but it is sufficiently obvious to our senses, the rays of light, or matter, emitted from the sun (as well as that from the fixed stars) fills the whole expanse; and as they are acknowledged to be material, it is demonstrable the heavenly bodies do not move in absolutely free and open space.

THE ebbing and flowing of the sea, the cause whereof is explained by Mr. FERGUSON and others, is produced as the most incontrovertible proof of the existence of the centripetal and centrifugal forces.—The following is extracted from tracts published by this author, p. 311.

“ THE cause of the ebbing and flowing of the sea on opposite
“ sides of the globe.

“ THE reason why the tides rise on the side of the earth which
“ is at any time turned towards the moon is plain to every one,
“ because her attraction must occasion a swelling of the waters to-
“ wards her on that side; but the cause of as great a swell at the same
“ time on the opposite side of the earth, which is then turned away
“ from the moon, has been very hard to account for, because the ri-
“ sing of the tide there is in a direction quite contrary to the
“ attraction of the moon; but this difficulty is immediately
“ removed

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“ removed when we consider, that all bodies moving in circles
“ have a centrifugal force, or continual tendency to fly off from
“ the centers of the circles they describe, and this centrifugal
“ force is always in proportion to the distance of the body from
“ the center of its orbit, and the velocity with which it moves
“ therein. When the body is large, the side of it which is
“ furthest from the center of its orbit, will have a greater degree
“ of centrifugal force than the center of the body has ; and the
“ side of it which is nearest to the center of its orbit, will have a
“ less degree of centrifugal force than its center has.

“ As the moon goes round the earth once every month in her
“ orbit, the earth also goes round an orbit every month, which is
“ as much less than the moon's orbit as the quantity of matter
“ in the moon is less than the quantity of matter in the earth,
“ which is 40 times: for by the laws of nature, when a small body
“ moves round a great one in free and open space, both these bodies
“ must move round the common center of gravity between them.

“ THE moon's mean distance from the center of the earth is
“ 240.000 miles ; divide this distance therefore by 40, the dif-
“ ference between the quantity of matter in the earth and moon,
“ and the quotient will be 6000 miles, which is the distance of

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“ the common center of gravity (between the earth and the
“ moon) from the center of the earth.

“ Now as the earth and moon move round the common cen-
“ ter of gravity between them once in every month, it is plain that
“ whilst the moon moves round her orbit at 240.000 miles from
“ the earth's center, the center of the earth describes a circle of
“ 6000 miles radius round the common center of gravity between
“ the earth and the moon, the moon's attraction balancing the
“ centrifugal force of the earth at its center.

“ THE diameter of the earth is 8000 miles in round numbers,
“ and consequently its semidiameter is 4000, so that the side of the
“ earth which is at any time turned towards the moon, is 4000
“ miles nearer the common center of gravity between the earth
“ and the moon than the earth's center is, and the side which is
“ then furthest from the moon is 4000 miles further from the
“ common center of gravity between the earth and the moon
“ than the earth's center is at that time.

“ THEREFORE the radius of the circle described by the parts
“ of the earth which come about towards the moon, by the
“ earth's diurnal motion, is 2000 miles ; the radius of the circle
“ described by the earth's center is 6000 ; and the radius of the
“ circle

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“ circle described by those parts of the earth which in re-
“ volving on its axis are the farthest from the moon, is 10.000
“ miles.

“ THE centrifugal forces of the different parts being directly
“ as their distances from the abovementioned common center of
“ gravity, round which both the earth and moon move, these
“ forces may be expressed by 2000 for the side of the earth
“ nearest the moon, 6000 for the earth's center, and by 10.000
“ for the side of the earth which is furthest from the moon.

“ BUT the moon's attraction is greatest on the side of the earth
“ next her, where the centrifugal force, or tendency to fly off
“ from the common center of gravity (and consequently from the
“ moon) is least ; and therefore the tides must rise on the side of
“ the earth which is nearest the moon by the excess of the
“ moon's attraction.

“ AS her attraction balances the centrifugal force at the earth's
“ center, it is plain, that the centrifugal force of the side of the
“ earth which is furthest from the moon, is greater than her at-
“ traction, and therefore the tide will rise as high on that side
“ from the moon, by the excess of the centrifugal force, as the
“ rise on the side next her by the excess of her attraction. And,

“ as the earth is in constant motion upon its axis, so as that any
“ given meridian revolves from the moon to the moon again in
“ 24 hours, 50 $\frac{1}{2}$ minutes, each place will come to the two emi-
“ nences of water, under and opposite the moon, in 24 hours,
“ 50 $\frac{1}{2}$ minutes, or have two tides of ebb and two of flood in that
“ time; for, as much as the waters rise above the common level
“ of the surface of the sea, under and opposite the moon, so much
“ they must fall below that level, half way between the highest
“ places, or at 90 degrees from thence.

“ ON these principles, it is equally easy to account for the
“ rising of the tide at the same time on both sides of the earth,
“ and this rising is made evident to sight in my lecture on cen-
“ tral forces, and the principles on which it depends are made
“ obvious to the understanding of all observers.”

THIS explanation of the ebbing and flowing of the sea on oppo-
site sides of the globe, being read in a cursory manner, seems per-
fectly simple, clear and satisfactory; the centrifugal force of the
earth round the common center of gravity between her and the
moon raises the water on one side, whilst the attractive quality
in the moon performs the same operation on the other.

UNFORTUNATELY for Mr. FERGUSON's theory, another motion obtrudes itself into this subject, which he seems entirely to have forgot; to be sure, since without it the matter is explained with so much perspicuity, it was not necessary to bring it into the question; but nature will pursue its course, and certainly the earth revolves round the sun, as well as round the common center of gravity between her and the moon; and if "all bodies have a centrifugal force, or constant tendency to fly off from the centers of the circles they describe," and this centrifugal tendency be always in proportion to the distance of the body from the center of its orbit, and the velocity with which it moves therein, will not this motion of the earth in its orbit round the sun affect the ebbing and flowing of the sea in some trifling degree? The center of the earth describes a circle round the common center of gravity between her and the moon, the radius whereof is 6000 miles, in 27 days, 7 hours, 43 minutes, of course the earth moves in this circle with the velocity of almost one mile in one minute: the radius of the circle which the earth describes in revolving round the sun, is in round numbers 95.000.000 miles, which it completes in 365 days, 6 hours, consequently it moves with the velocity of about one thousand miles in one minute.—Now, if we suppose this theory of Mr. FERGUSON's to be true, and the powers he has laid down sufficient to raise the waters, as we find they are raised

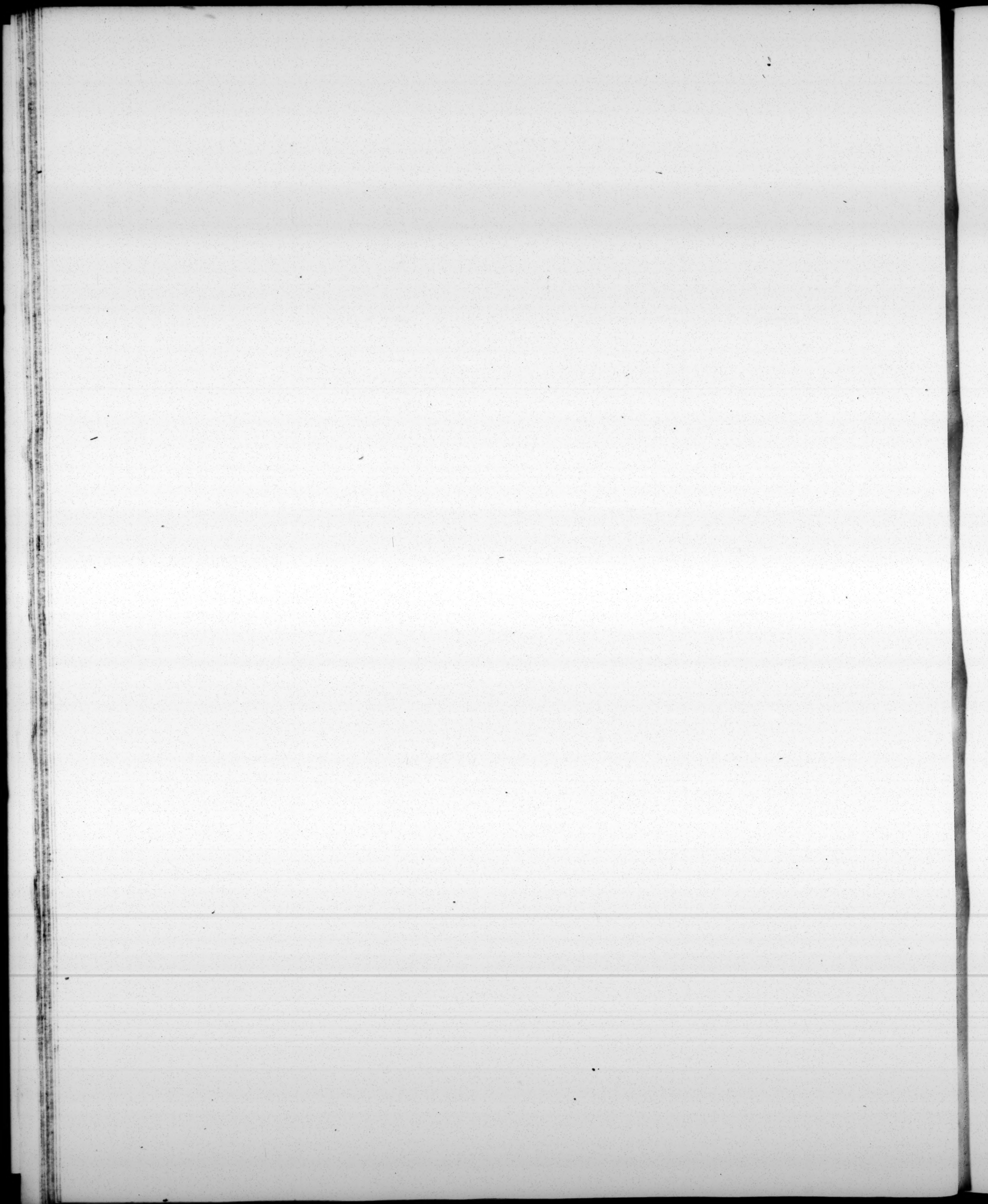
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eight or ten feet, how high may we suppose they would be raised, by deduction from his own laws, by the power above stated?

BUT considering the motion of the earth round the sun as negative in this case, how happens it that the tides are not highest directly under and opposite the moon? if there were but a few minutes difference, one might suppose it arose from some subordinate cause, but when we find there are three or four hours, there is certainly sufficient reason to doubt whether the cause here assigned be indeed the true cause.

WHAT has been said, will, I flatter myself, be thought sufficient to justify a suspicion that the Newtonian theory of the laws of motion is erroneously founded; I at first intended to have controverted the present system of philosophy in a much greater number of points, but I shall occasionally hereafter be obliged to mention other leading principles which will naturally present themselves to the subject then in question, and the great variety of opinions renders it extremely difficult to ascertain what is considered as the cause of any, except the most leading phenomena.

THE assertions of one philosophical writer are generally refuted by another, and not unfrequently the same writer refutes his own positions in the subsequent parts of his work. This is no proof of want of ability in the author, but must ever be the case whilst the principles of the subject are unknown, or involved in obscurity and error.



S E C T I O N II.

T H E O R Y.

IF the motions of the heavenly bodies, as well as the various phenomena of gravity, magnetism, formation of clouds, &c. be considered as necessary effects, these appearances must be produced by certain original universal laws, or properties existing in matter from its first creation; it is the business of philosophy, by investigating the phenomena, to determine what these properties are.

It must be confessed there are many difficulties to surmount before we can arrive at this knowledge; yet I cannot think it entirely above the reach of our capacities, and the great lights thrown upon these subjects by late experiments and consequent discoveries, are fully sufficient to enable us to establish a more consistent system than was adopted by our forefathers.

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By examining minutely the various efforts of nature, we are enabled properly to distinguish causes from effects, without which it is impossible our inquiries should be pure or sufficient.

GOD, as the Creator, must be considered as the first cause, so that the extent of our researches necessarily terminates in the first of second causes.

THE attraction of gravity, however, cannot be considered in this light, but merely as an effect produced by some primary cause; to this acceptance Sir ISAAC himself expressly confines it, for he says, "I do not consider gravity as an essential property stamp'd on bodies, but only deduce from appearances that bodies do tend towards each other, which tendency I call the attraction of gravity."—Nor has attraction, in the more indefinite sense of the word, any greater right to a place in the catalogue of causes; this assertion will undoubtedly appear true, if we can prove that the atoms or particles of bodies adhere together from an external rather than an internal cause; or in other words, that this attachment is not inherent to the particles themselves, but arises from the impulsive power of an external agent. A variety of experiments clearly shew that this effect is produced by an outward impulse: *e. gr.* If the surface of a body be rubbed, matter immediately issues, particularly those bodies most firmly united, as metals, &c.; some
late

late writers call this a fine subtle, or electric matter, the particles whereof they assert have a strong power of repelling each other, and of attracting the particles of the substances in which they are contained; or that the particles of bodies attract those of the electric matter; or otherwise, that they mutually attract each other. It is of little consequence to the subject before us whether this affection be mutual or arbitrary, the whole of the question is, does there exist in nature any such property that may with propriety be called a cause? If there be any power of attraction subsisting between the particles of a body, and the particles of fine subtle matter, it does not seem reasonable that rubbing the surface should destroy the power, unless it be supposed, the force exerted presses the particles of elastic matter into a smaller quantity of space than their natural disposition inclines them to occupy, that in springing back they force themselves beyond the sphere of attraction, and thereby repel each other from the body. This is certainly placing the doctrine in the most favourable point of view; I leave it to others to decide how far it appears consonant to reason and the nature of things. But what may be said to amount to demonstration that it is an external power which preserves the electric matter in the body, is, if the substance has any sharp points, these fine subtle particles cannot be confined, nor prevented from issuing, which is evidently owing to the points exposing so small a portion of surface. Now, if there be an outward

power sufficient to detain these active particles of matter, it is certainly sufficiently powerful to compress the particles which compose bodies into the state of cohesion wherein they are found. Innumerable other instances might be adduced to prove that cohesion arises from an *external* impulse; the matter instantaneously follows the percussion of the flint and steel; or observe the same phenomenon more perfectly in the copious flow of matter from the dry stone of a razor-grinder's machine; the action of culinary fire, volcanos, water spouts, the various operations of magnetism, electricity, &c. are altogether so many demonstrable proofs of this plain truth, that to deny it would be to deny our senses.

SINCE then neither attraction nor gravity ought to be considered otherwise than as necessary effects, flowing from some permanent cause, it is obvious our inquiries should penetrate deeper, even to the primary cause thereof; having minutely investigated, combined, and compared the above, and the various operations of the physical world, it has induced me to lay down the following as general principles, (*viz.*)

First. THAT all bodies whatever are composed of two distinct heterogeneous species of particles, which I will call simply inert particles, or particles of passive matter; and elastic particles, or particles of active matter.

Secondly.

Secondly. THAT the inert passive particles are particles of water, being perfectly incompressible and inelastic; and that all other particles of matter are as perfectly volatile, compressible, and elastic, having the properties of expanding themselves *ad infinitum*.

Thirdly. THAT from their incompressibility and inelasticity, the watery particles have no power but of simply falling into any direction.

Fourthly. THAT from their being directed to a center, by the cause hereafter explained, arises all that power of gravity observed in the various phenomena.

Fifthly. THAT the active, compressible, elastic particles, are under every state of compression inclinable to motion.

Sixthly. THAT this elastic power in matter is the cause of *cohesion, gravitation, fermentation, coagulation, ebullition, &c. &c.*

Seventhly, THAT the inelastic passive, and the elastic active matter, are the only perfect elements, by the varied combination whereof every substance is produced: it seems evident these

two are the only primary principles(*a*), for the particles of all bodies which come under our observation being separated, resolve into these two heterogeneous species of matter.

WE may safely assert that the particles of water are heterogeneous to the other particles of matter; their inertness, incompressibility and inelasticity, are properties directly opposite to the extreme elasticity, &c. of the other; and that it is possessed of these properties the generality of philosophers agree, and prove by a great variety of experiments; or if water be in any degree compressible, it is only so far as it may contain elastic matter within the interstices of its particles.—Mr. LOCKE, speaking of the Florentine experiment, is of opinion that a primary particle, or spherule of water, is a perfect impenetrable solid, which he asserts is the reason of its incompressibility in that experiment, which was thus performed: “ A hollow globe of gold was filled
“ with water, and then exactly closed, the globe thus closed was
“ put into a press driven by the force of screws, the water, find-
“ ing no room for a nearer approach of its particles towards each

(*a*) Whether the principles in bodies whence arise taste, smell, &c. are mechanically the effect of motion (or proceeding from created essence in the active part of matter), does not in the least affect the axioms here laid down, with respect to the laws of motion, *e. gr.* we know brandy is not rum, yet the active particles of both when in motion uniformly expand and recede from each other; so likewise does tallow, tar, turpentine, oil, hemp, hay, straw, &c. &c.

“ other,

“ other, made its way through the pores of that close metal,
“ standing like drops of dew upon the outside, before the globe
“ would yield to the violent pressure of the engine.”

MR. CANTON has by very curious experiments endeavoured to prove that water is in some degree compressible; but whether these experiments are sufficient to decide that a primary particle, or spherule of water, is not a perfect impenetrable solid may be reasonably doubted. The means he used to deprive the water of its air could not be quite competent to the purpose, and it is impossible but his experimental instruments must be a compound of compressible, as well as of incompressible matter; duly considering these things, is it not more probable, that water is not possessed of the least compressibility, than that we can determine it is so, one part out of twenty one thousand seven hundred and forty?

SIR ISAAC NEWTON, as well as all our modern philosophers have agreed, that the particles of active matter have this inherent property, of separating and expanding themselves *ad infinitum*, and that they are perfectly volatile and compressible: the definition of light and fire by this great author being applicable to the purpose, is here subjoined.

“ *First.*

“ *First.* WE find by experience that the parts of all bodies
“ when agitated to a certain degree, do so act upon animal bodies
“ as to produce the sensation of heat.

“ *Secondly.* SUCH an agitation, or intestine commotion of the
“ parts of bodies may be effected by various means, as friction,
“ percussion, fermentation, vital motion, the action of light, &c.

“ *Thirdly.* THE standard degree of warmth, or heat, is that of
“ an animal body, or in other words, if the parts of any body
“ have a greater degree of motion than the parts of the animated
“ body, as the hand, it is warm, or hot; but if they have a less
“ degree of motion than those of the hand, we say they are cold;
“ lastly, if the motion of the parts are the same in both, we then
“ say such a body is neither hot nor cold, and hence it appears
“ that the ideas of heat and cold are only in a comparative
“ degree.

“ *Fourthly.* THE parts of bodies when agitated or heated beyond
“ a certain degree, emit or throw off such fine subtle particles,
“ or effluvia, which shine or excite the idea of light, and which
“ therefore we generally call particles of light.

“ *Fifthly.*

“ *Fifthly.* WHEN the particles of bodies are so violently agitated
“ that they not only throw off lucid particles, but also shine
“ themselves, then we say it is a body of fire, when the particles
“ are not in a fuming state ; but when they are, we call that lucid
“ flame a flame of fire.

“ *Sixthly.* THE intensity of the action of ignited bodies depends
“ as well on the density as the velocity of the parts, and when
“ both these are in an extreme degree, the momentum or whole
“ force of the heat becomes intolerable, and inconsistent with
“ the state of a natural body, and its action is in this case what
“ we call burning.

“ *Seventhly.* THERE are some cases when the parts may have
“ sufficient velocity to appear lucid, but not dense enough at the
“ same time to burn.

“ *Eighthly.* THE motion with which the parts of bodies are thus
“ agitated to emit light and heat is of the vibrating kind,
“ because the motions and directions of the particles in this case
“ may become uniform, consonant, and harmonious ; and all
“ conspire to produce the effect which they could not do by a
“ confused contrary motion of the parts.”

QUERY. How could these motions be produced, but by the active particles whereof bodies are composed having a natural propensity to expand and recede from each other? Further, we can produce heat, or fire, by friction, percussión, &c.; but wherefore does this friction or this percussión produce heat? *First*, by destroying the equilibrium subsisting between the active and passive particles: *secondly*, by taking off the weight of the atmosphere or pressure of the watery particles (for the atmosphere is a compound of water and elastic matter like other substances, only in an extreme rarified state), when the particles of active matter composing the body immediately exert their innate property of expanding and receding from each other, passing off in sparks of fire.

INDEED were it not for the inertness, incompressibility, and inelasticity of the watery particles, the system of nature could not be supported, for it is by the passive matter the active particles are kept together: and, considering matter to have been in what is called a fluid state, there is nothing more evident than that the greatest part of the passive, incompressible, inert particles, would be found upon the surfaces of bodies formed therefrom. Lastly, if any doubt of the truth and reality of the existence of these two distinct heterogeneous species of particles, of their properties,

properties, and of their acting as I have endeavoured to point out, still remains; let electricity be consulted, when we shall find every experiment examined under this idea, perfectly consonant and consistent with the principles here advanced.



S E C T I O N III.

THE PRECEDING PROPOSITIONS APPLIED TO THE SOLUTION OF THE
VARIOUS PHENOMENA OF THE HEAVENLY BODIES.

IN the foregoing Section I have asserted that all bodies whatever are composed of two distinct heterogeneous species of matter, the one active, the other passive; assuming therefore that the celestial bodies are thus compounded, let us examine how far their phenomena justify the assertion.

THE *first* consequence which necessarily follows from these principles is, that the particles of elastic matter being continually pressed upon by the weight of the inelastic, must of course be surrounded by those particles.

Secondly. THE active particles must be constantly forcing through, separating, and carrying upwards the passive watery particles, by which means the rarer mediums of atmospheres are formed.

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THE truth of these propositions might be easily and incontrovertibly proved if we knew the exact proportionate power of elasticity; that is, what force active matter of any given density shall have, and in what degree the power increases or decreases. It were an easy matter to lay down suppositious rules for this proportion, and thereby explain the whole with as much apparent clearness as Sir ISAAC NEWTON did by the attraction of gravity, after having asserted that the power decreased as the squares of the distance increased; but as I do not wish, if I cannot throw any new light upon philosophy, to add to the perplexity in which it is already involved, I shall be very careful not to *assert* any position which is not founded upon certain known fact.

IF this idea of the activity of matter be just, it must of necessity increase in velocity in proportion as it increases in rarity, but the degree of this increase cannot be ascertained.

THE expansive power of any body must be proportionate to its quantity of matter, being the sum of the united forces of all those single particles whereof it is composed. Thus, suppose a corpuscle to be emitted by any body into its atmosphere containing one thousand particles, that each particle has a force equal to any given weight, say an ounce, the sum of their united forces will consequently be equal to one thousand ounces; now the density
of

of the atmosphere decreasing in a certain proportion to the distance from the body, its pressure upon the corpuscle as it ascends or is forced upwards by the action of those coming after it, will decrease in a similar degree, and at a certain distance, the expansive force of the one, and the pressure of the other will be in equilibrio; at a greater distance from the center, the particles which compose the corpuscle will expand and recede from each other; hence it appears, that larger bodies exposing less surface, in proportion to their cubical quantities, than smaller ones, act with greater proportionate force; so that by examining and comparing the respective distances, magnitudes, and powers of the heavenly bodies, we shall easily be convinced of the truth and consistency, or falsehood and inconsistency, of these doctrines(*b*).

THE turning of the sun and the planets upon their axes is a phenomenon which I believe no astronomer has ever attempted to explain, but by supposing this whirling (like the projectile force) to have been first communicated by the arm of the Deity, and the bodies being situate in perfect vacuums will naturally persevere in these motions without any diminution.

(*b*) The author of this short treatise does not pretend to explain all the minutiae of the action of matter; it would require a great number of years of intense application; he has here given what he conceives to be the great outlines, hoping the hints will be of use to philosophers in their researches, and tend to the advancement of truth and useful knowledge: every attempt, however feeble, if it carries the least appearance of utility, ought to be examined. The most useful discoveries have arisen from the most trivial accidental occurrences; one man suggests an idea, another improves upon it, and a third raises it to a still higher degree of perfection, and deduces unthought-of advantages therefrom.

BUT

BUT as the celestial space is not a perfect void, the above supposition is certainly erroneous, and therefore we must endeavour to assign some probable cause for these motions: the different velocities of the bodies round their axes, some turning extremely swift, whilst others scarce move at all, is a strong presumptive proof that this phenomenon is the effect of immutable mechanical agency. It is an axiom in *physics*, that, If a body be urged by equal and contrary actions or pressures, it will remain at rest; but if one of these pressures be greater than its opposite, motion will ensue towards the parts least pressed.

THE particles of fine active matter are continually issuing from the body of the sun, from the bodies of the planets, and from the bodies of the fixed stars, in every direction with great velocity; light passes from the sun to the earth in $8\frac{1}{4}$ minutes, which is at the rate of 164.494 miles in a second; and as the motion of the elastic particles increases in proportion to their rarity, their velocity must be much greater at the orbit of the earth, than at their first emission from the sun's surface, and will continually increase in proportion as the distance and rarity increases; so that the velocity of the particles even at the orb of saturn must be extreme; hence the momentum must be inconceivably great when the particles of matter emitted by the sun, and those emitted by the fixed stars meet and resist each other; which

which will be the case (as appears by the phenomena of magnetism and electricity) where the particles are of similar density.

Now as the fixed stars are not of equal magnitudes, nor at equal distances from the sun, nor from each other, it follows, that the momentum or resistance cannot be equal on every side; from this unequal resistance, unequal reaction must ensue, and thereby motion is communicated to the body of the sun. To render this idea if possible more familiar, see plate II. where fig. 1. represents so many hollow globes of metal of different magnitudes, perforated with holes on all sides, and filled with a composition similar to that of which rockets are made; these balls so filled being suspended upon pointed rods, at equal or unequal distances, and the whole set on fire by one common explosion of gunpowder, a variety of motions would immediately ensue from the inequalities of the powers of the different bodies.

THE revolving of the sun upon his axis is the cause of the annual and diurnal motions of the planets, which are very properly only so many satellites circulating round, and governed by the sun as their primary; the space where the matter emitted by the sun, and that emitted by the fixed stars is of equal density, may be considered as the boundary of his atmosphere, or the

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limits

limits of his power ; within this space it is obvious the whole of the matter will circulate with the sun, and all bodies situate therein will be subject, in a greater or less degree, to the uniform action of this matter ; this explains why the planets and satellites move in their orbits, and upon their axes in the same direction, viz. from west to east.

SIR ISAAC NEWTON, to render his theory of attraction and gravity consistent, was obliged to consider the bodies of the planets as of different densities ; these calculations of densities are merely hypothetical, as they cannot be deductions from facts, but they are such as must necessarily subsist upon the principles of his theory ; it is not, however, very conformable to the simplicity observable in nature, to suppose the specific weight of the body of saturn to be as that of cork, and of mercury as that of lead. I know it is urged, that mercury being situate so near the sun, it was necessary he should be composed of very dense materials to bear so extreme a degree of heat ; but when it is considered, that all hard dense bodies have a much greater retention of heat than rarer ones, the consistency of the conclusion vanishes.

If this theory of expansion be true, it follows, that all the heavenly bodies are compounded of the same, or nearly the same proportionate quantities of elastic and nonelastic particles ; this
being

being admitted, to compare the power of the sun with that of any planet, we have only to ascertain the difference between the cubical and superficial quantities in each: but here again we are surrounded with difficulties, as the opinions respecting the magnitudes and distances differ materially; nor is this to be wondered at, since the angles by which they are calculated are so extremely small, and the quantity of refraction so very uncertain, it is almost impossible any two observations should agree: however, supposing the moon to be distant from the earth $58\frac{1}{2}$ semidiameters thereof, or 234.000 miles, and the sun 95.000.000 miles, we may consider the distance of the planets from the sun, the proportion which their powers bear to that of the sun, and the consequent diameters of their atmospheres, to be such as stated in the ensuing explanation of the general and particular phenomena of each planet; and first (c)

MERCURY. The phenomena of this planet will be easily understood by referring to plate II. fig. 2. where S represents the body of the sun, M that of mercury, C C C C a sphere, the circumference whereof passes through the center of the planet; the distance from

(c) It is proper in this place the reader should consult plate I. which will convey the idea in what manner the sun acts upon the bodies and atmospheres of the planets, more justly than a multiplicity of words.

a to *a* is a superficial mile upon the surface of the sun, and from *b* to *b* upon that of mercury; now, as the quantity of matter (agreeable to the above laws) emitted by the superior prescribes the quantity to be emitted by the inferior body, it will be found, by comparing the cubical and superficial quantities in each, that the power of *aa*, or the quantity emitted in a superficial mile upon the body of the sun, will be 54.000 times greater than will be emitted in a superficial mile upon the body of mercury, *bb*; consequently the power of the sun to that of this planet is as 4.650.000.000 to 1.—The distance of the orbit of mercury from the sun being 37.000.000 miles, the diameter of the sphere C C C C must be 74 millions, and as the power of the sun over this planet is as 4.650.000.000 to 1, the diameter of mercury's atmosphere must be 44.500 miles. that is, the distance of 22.250 miles from the center of the planet, the particles of matter emitted by the sun, and those emitted by mercury are of similar density.

THE sun, and the elastic particles emitted therefrom, or the whole of his extensive atmosphere revolving round together like one entire body, it is evident these particles will impel and endeavour to force round the respective bodies and atmospheres of the planets situate therein; this naturally leads us to inquire why they do not perform a revolution in the same time; which must be owing to a vis or tendency the bodies have to remain at rest:

this

this power I consider arises from the system being surrounded by fixed stars, which are continually emitting particles of matter into every direction, every body, and the atmosphere of every body situate within this system will be acted upon by the force of these particles on every side; and the particles from the different stars thus striking on opposite parts must counteract each other, and endeavour to preserve the bodies of the planets at rest: hence it follows, the larger a body the greater will be its resistance, or tendency to remain at rest; and the rarer the medium of the sun's matter at the orbit of a planet, the less power will it have to impel it in its circular course; hereby we are furnished with the reason why those bodies which are nearest the sun move with greater velocity than the more distant ones. Mercury passes over 1583 miles of his orbicular circuit in one minute, whereas the earth passes over only 966 miles in the same time. Although no observation can determine that this planet turns upon his axis, yet, as the cause which produces these motions acts upon mercury in the same manner as upon the other planets, there is no room to doubt but a similar effect is produced.

VENUS. The distance of the orbit of this planet from the sun being 69.000.000 miles, her cubical and superficial quantity compared with the sun, appears to be as 1 to 50.000.000, and therefore the diameter of venus's atmosphere is 376.000 miles.

THE

THE same action which impels mercury also carries this planet round the sun, viz. the revolving of his atmosphere.

WRITERS differ widely respecting the period of venus's revolution upon her axis; some assert she is more than 25 days, whilst others maintain a circulation is completed in as many hours; the bulk and situation of this planet induce me to believe the latter opinion is very near the truth.

THE cause of this, as well as of all the other planets turning upon their axes, will be very familiarly explained by referring to plate I. The figure represents the sphere of the atmosphere of a planet, acted upon by the particles of the sun's atmosphere; now the distance from the sun to A, being less than to C, it follows that the matter must be denser at A than at C; and the velocity of the circular motion of the sun's atmosphere being much swifter than the orbicular motion of the planet, the matter will certainly be more powerful at B than at D, so that the distance will be greater from the center of the planet to C than to A, and to D than to B.

FROM these premises, it is evident the action or compression is not equal upon opposite sides of the planet, and therefore the matter emitted by the planet, and by the consequent unequal
reaction

reaction of this matter, the body of the planet itself and its atmosphere will be impelled from A to B, and from B to C, with a velocity proportionate to the inequality of the power on opposite sides of the body.

THE earth, being distant from the sun 95.000.000 miles, by comparing, as before, their cubical and superficial quantities, the proportion of power appears to be as 1 to 50.000.000, and of course the diameter of the earth's atmosphere must be 515.000 miles; nothing new can be said respecting the motion of the earth in its orbit, the solution of this phenomena is the same throughout the system. We consider that the earth revolves upon its axis from any star to the same star again in 23 hours, 56 minutes, 4 seconds. I have some reason to suspect this rotation is not quite so uniform as we generally imagine; but whether the inequalities are sufficient to be discovered, I cannot at present determine, as it requires a number of accurate observations.

THE moon, being 234.000 miles from the center of the earth, if their cubical and superficial quantities be compared (in the same manner as those of the planets and the sun), their proportionate power will be found as 260 to 1, consequently the diameter of the moon's atmosphere, were she unconnected with any other body, would be 74.000 miles.

It is observable the moon moves slower in her orbit round the earth than any other body round its primary; this is owing to her situation so near the extremity of the earth's atmosphere, and also to the power of the earth being counteracted by the action of the sun; the various alterations in the degrees of these two powers upon the moon in different parts of her orbit, is the cause of that infinite variety so remarkable in the motions of this satellite; but as these variations deserve to be examined more minutely, an entire Section shall be dedicated to the subject, in the ensuing part of the work.

MARS. The distance of this planet's orbit from the center being 145.000.000 miles, we find, by the preceding rules, the power of the sun to that of mars, as 544.000.000 to 1, therefore the diameter of his atmosphere is 477.000 miles; with respect to the phenomena of this planet, they are naturally resolved by the same principles as the foregoing ones. The motion in his orbit is proportionally slower, as the rarity of the medium and consequent resistance of the planet is greater than that of the earth, venus, or mercury: the period wherein mars completes a revolution upon his axis, is nearly the same as that of the earth and venus.

JUPITER.

JUPITER, *with his four satellites*, revolves at the distance of 495.000.000 miles from the sun; their powers being compared, the proportion appears to be as 5.000 to 1, and the diameter of jupiter's atmosphere 58.000.000 miles; the annular motion of this planet is perfectly consistent to these principles; but the extreme velocity with which jupiter turns upon his axis deserves to be more particularly examined, for it may at first seem difficult to conceive, how so large a body should be acted upon with sufficient force to produce a revolution in 9 hours, 56 minutes, especially as the power of the sun is superior only as 5.000 to 1.

BUT, jupiter being much the largest planet in the system, and the medium of the sun's atmosphere at the distance of his orbit extremely rare, the atmosphere of this planet is of course very extensive; so that the density of the particles of the sun's atmosphere is materially greater on the side of jupiter's atmosphere next him, than on the opposite side furthest from the sun; and as the motion of this planet in his orbit is extremely slow, compared with the circular motion of the sun's atmosphere, the particles must be much denser on the western, than on the eastern side;—hence, as the velocity with which any body moves is proportionate to the inequality of the action on opposite sides, it appears, the extreme swiftness wherewith this planet turns upon his axis is perfectly consistent to these principles, such as must

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necessarily

necessarily arise if they are just. The reasonableness of this explanation will appear more striking, by referring to the preceding account of the cause of the planets revolving upon their axes.

THE dimensions of jupiter's satellites are not sufficiently known to compare their powers with that of their center; but to throw some light upon the subject, as well as to prove the consistency and agreement of their phenomena to the principles of this theory, suppose the nearest is of similar size with the earth, whose diameter is 8,000 miles; then, as the distance of its orbit from the center of jupiter is in round numbers 230,000 miles, by comparing the cubical and superficial quantities, the proportion appears to be as 10,500 to 1, and of course the diameter of its atmosphere is 21,000 miles.—Now, as jupiter revolves upon his axis in 9 hours, 56 minutes, this satellite being only 230,000 miles from the center of so large a body, it is evident, the medium at so small a distance must be extremely dense, and therefore the satellite must be impelled in its circular course with great velocity; which is accordingly the case, an annulation being completed in 1 day, 18 hours, and 36 minutes.

SATURN, *with his five moons*, being considered at the distance of 908,000,000 miles from the center of the sun, the difference of their powers are as 14,600 to 1, and therefore the diameter of

saturn's

Jupiter's atmosphere is 740.000.000 miles; the motion of this planet in his orbit is perfectly conformable to the foregoing rules, such as the principles must infallibly produce.

FOR want of perceptible spots upon the surface of Jupiter, astronomers have not been able to determine whether he turns upon his axis; but, judging from cause to effect, it follows he has such a motion: the revolving of his satellites proves the matter beyond a doubt, and from their velocities it may be gathered, that he completes a revolution upon his axis in about $10\frac{1}{2}$ hours, that is, considering the first satellite at the distance of 140.000 miles.

IF the body of Jupiter was equal in magnitude to Jupiter, he certainly would have revolved upon his axis in less time, and for want of that power is the reason his motion is slower; perhaps it may be urged, If the velocity of a body on its axis depended on its magnitude, the sun should turn much faster than any of the planets; but if we refer to plate I. and consider the central body, the sun, this difficulty is removed, as we there see the stars press on the atmosphere of the sun in every direction, consequently the more equal the pressure, the less the motion.

COMETS. I have already shewn, and shall hereafter adduce other indubitable proofs, that the celestial space is not a vacuum, and therefore the theory laid down by Sir ISAAC NEWTON for explaining the phenomena of comets, cannot be justly founded. With the utmost deference for his great name, and still greater abilities, it must be confessed some of Sir ISAAC's suppositions and calculations respecting these bodies, are rather too inconsistent to be read without exciting risible emotions. In one place he suspects, it is chiefly from comets that spirit comes, that is, the pure and most subtle part of matter; this is surely a most extravagant assertion to come from a man who had studied nature with so much attention. He calculates that the comet which appeared in 1680, when nearest the sun, might have acquired a degree of heat two thousand times hotter than red hot iron. Mr. FERGUSON takes up the idea, and supposes, that the comet thus heated would retain a sufficiency of heat to last until its return to the sun, though the period should be more than twenty thousand years; he further says, "this comet at its greatest distance is
" 11.200.000.000 miles; and at its least distance, within less than
" a third part of the sun's semidiameter from his surface, flying
" with the amazing swiftness of 880.000 miles in an hour." Is it not exceeding curious, that this body in a few days (for it cannot be in such an intense situation a great number) should have acquired such an extreme degree of heat as shall last it twenty
thousand.

thouſand years? For, though a fire be ever ſo intenſely hot, it requires a very conſiderable time to communicate any large portion of heat to a body of great magnitude.—That the ſun does act upon the bodies of the comets is plain, from the chaotic appearance of their atmospheres, and additional length of their tails; but theſe and every other phenomena of comets may, I preſume, be much more naturally explained upon the principles of the foregoing theory.

THE directions in which comets move being quite oppoſite to thoſe of the planets, ſome other cauſe, and not the circulation of the ſun's atmosphere, muſt be productive of this contrary effect; and though it is evident this power will endeavour to influence the comets, as well as the planets, when they come within the ſphere of its action, yet the velocity of theſe bodies (ariſing from another power) being ſo great, it is eaſy to conceive why they are not ſenſibly affected by the uniform motion of the ſun's atmosphere from weſt to eaſt.

COMETS are, I believe, compoſed of the ſame materials the earth, the ſun, and all the other bodies are, viz. of elastic, active, and of nonelastic, paſſive particles; but their appearance, and likewise their motions, is a confirmation that the particles are not in the ſame ſettled ſtate.

COMETS. I have already shewn, and shall hereafter adduce other indubitable proofs, that the celestial space is not a vacuum, and therefore the theory laid down by Sir ISAAC NEWTON for explaining the phenomena of comets, cannot be justly founded. With the utmost deference for his great name, and still greater abilities, it must be confessed some of Sir ISAAC's suppositions and calculations respecting these bodies, are rather too inconsistent to be read without exciting risible emotions. In one place he suspects, it is chiefly from comets that spirit comes, that is, the pure and most subtle part of matter; this is surely a most extravagant assertion to come from a man who had studied nature with so much attention. He calculates that the comet which appeared in 1680, when nearest the sun, might have acquired a degree of heat two thousand times hotter than red hot iron. Mr. FERGUSON takes up the idea, and supposes, that the comet thus heated would retain a sufficiency of heat to last until its return to the sun, though the period should be more than twenty thousand years; he further says, "this comet at its greatest distance is 11.200.000.000 miles; and at its least distance, within less than a third part of the sun's semidiameter from his surface, flying with the amazing swiftness of 880.000 miles in an hour." Is it not exceeding curious, that this body in a few days (for it cannot be in such an intense situation a great number) should have acquired such an extreme degree of heat as shall last it twenty thousand

thousand years? For, though a fire be ever so intensely hot, it requires a very considerable time to communicate any large portion of heat to a body of great magnitude.—That the sun does act upon the bodies of the comets is plain, from the chaotic appearance of their atmospheres, and additional length of their tails; but these and every other phenomena of comets may, I presume, be much more naturally explained upon the principles of the foregoing theory.

THE directions in which comets move being quite opposite to those of the planets, some other cause, and not the circulation of the sun's atmosphere, must be productive of this contrary effect; and though it is evident this power will endeavour to influence the comets, as well as the planets, when they come within the sphere of its action, yet the velocity of these bodies (arising from another power) being so great, it is easy to conceive why they are not sensibly affected by the uniform motion of the sun's atmosphere from west to east.

COMETS are, I believe, composed of the same materials the earth, the sun, and all the other bodies are, viz. of elastic, active, and of nonelastic, passive particles; but their appearance, and likewise their motions, is a confirmation that the particles are not in the same settled state.

It has already been observed, that if a body emits equally into every direction, and the expanding matter meets with equal resistance on every side, the body will remain at rest; but if the expansive power be unequal on opposite sides, motion must be communicated to the body, as well as if the emitted particles were resisted unequally. From the dark chaotic appearance and prodigious extent of the atmospheres of comets, I am induced to think they are bodies newly formed, and that the elastic and inelastic matter is not uniformly disposed; that is, the elastic active particles of matter are not properly surrounded and compressed by the inelastic, passive, or watery particles; now, since the inelastic particles act as a regulator, suffering the elastic particles to pass through the interstices, it is plain, that if the active matter is not uniformly compressed, the expansive force will not be alike on every side; and the body will remain in this state so long as the inelastic particles are unequally disposed; or are insufficient to regulate the expansive force of the elastic. Let my ideas in this particular be rightly understood: I do not mean to assert, that the watery particles are the sole cause why bodies expand so slowly, though I conceive they are the principle: if a body were composed entirely of elastic matter, the action of the surrounding bodies might keep the particles in some degree together, but then they would be quite in a fluid state; for, as to the attraction of cohesion inherent in the minute particles of matter,

matter, it is evident no such principle does exist, and every person who has studied nature through the medium of electricity, must be satisfied of this truth; so that if a body were formed of active matter alone, and the particles afterwards separated, they never would combine again of themselves; but if a certain quantity of nonelastic particles be mixt with them, bodies will ever be forming and separating.

I do not pretend to assert how, or from whence comets are formed, but I think it extremely probable they are recent combinations of matter, where the two species of particles are not in a proper state of equilibrium. To determine how far this supposition is reasonable, let us see how justly it agrees with the phenomena of these bodies. Fig. 2. plate I. represents the body of a comet with its atmosphere; its several positions point out the track which it pursues through our system; let us suppose its first appearance to be at A, and further, that the body is in such a state as to emit twice, thrice, or ten times as much matter on the side *a*, as on the opposite side *b*: this being the case, the comet must necessarily be forced by this disproportion of its power on opposite sides, with a velocity proportionate to this difference, to its situation at B, and in like manner from B to C: the comet being arrived at C, the power which forces it towards the sun acting from *a* to *a*, must here be counteracted by the superior action of the

the sun, which will press upon its atmosphere with greater force at the part *b*, than at *i*, the distance from the center of the sun to the former being less than to the latter: now, the comet being impelled by its power *a a*, and resisted most by the sun at *b*, will yield from the counteraction of these two opposite forces towards *i*, which by altering the position of the power *a a*, will give a different direction to the body, and the force *a a*, will not now impel the comet directly onwards to the sun, but will force it on the curve *K* to *E*, and from thence to *F*; where the position of its body being entirely reversed (by the causes abovementioned), the action of the power *a a* will impel the comet with as great velocity from the sun, as it did before towards it.

THE tails of comets are, I think, occasioned by the motion of the particles emitted from the sun being so much swifter than the advancing, or receding motion of the comet; if particles pass from the sun to the earth at the rate of 164,494 miles in a second, it is evident that they move much swifter than comets, for the comet which appeared in 1680, when it moved with the greatest celerity, did not exceed 2000; since, therefore, the matter from the sun expands in every direction, those rays that strike upon the matter emitted from the comet, and pass into its confused chaotic atmosphere (which is composed of elastic and inert particles, the active forcing the passive backwards and forwards

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in every imaginable direction) must be almost or entirely stopped by the watery particles; but the particles of matter from the sun, that pass just within and upon the outer edge of the comet's atmosphere, will force a great number of the gross particles along with them, consequently the matter must always be denser on that side of the comet furthest from the sun; and as the reflection of light will be reciprocal to the density, it evidently must be brighter, and cause the appearance of a tail.

MR. BRYDONE, in his Tour through Sicily and Malta, Letter 24th, gives a particular account of a comet which he observed; and not only offers some hints upon this particular part of philosophy, but seems to consider the Newtonian theory in general as very unsatisfactory. As his observations coincide in some measure with my ideas, a few extracts from his letter are here subjoined.

“ OUR comet is now gone, we first observed it on the 24th. It
 “ had no tail, but was surrounded by a faintish, ill-defined light,
 “ that made it look like a bright star shining through a thin
 “ cloud. This, in all probability, is owing to an atmosphere
 “ around the body of the comet that causes a refraction of the
 “ rays, and prevents them from reaching us with that distinctness
 “ we observe in bodies that have no atmosphere.—We were still
 “ the more persuaded of this two nights ago, when we had the

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“ good fortune to catch the comet just passing close by a small
“ fixed star, whose light was not only considerably dimmed, but
“ we observed a sensible change of place in the star, so soon as
“ its rays fell into the atmosphere of the comet, owing, no
“ doubt, to the refraction in passing through that atmosphere.”

—————“ It is now immerfed in the rays of the fun, and has cer-
“ tainly got very near his body. If it returns again to the regions
“ of space, it will probably be vifible in a few days ; but I own I
“ fhould much doubt of any fuch return, if it is really by the
“ attraction of the fun that it is at prefent carried with fuch
“ amazing celerity towards him. This is the third comet of
“ this kind, whose return I have had an opportunity of watch-
“ ing ; but never was fortunate enough to find any of them after
“ they had paffed the fun : though thofe that do really return,
“ appear at that time much more luminous than before they
“ approached him.—The aftronomy of comets, from what I can
“ remember of it, appears to be clogged with very great difficul-
“ ties, and even fome feeming abfurdities. It is extremely diffi-
“ cult to conceive that thefe immense bodies, after being drawn
“ to the fun with the inconceivable velocity of a million of miles
“ in an hour, when they have at laft come almoft to touch him,
“ fhould then fly off from his body with the fame velocity they
“ approached it ; and that too by the power of this very mo-
“ tion that his attraction has occafioned.—The demonftration of

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“ this I remember is very curious and ingenious; but I wish it
“ may be entirely free from sophistry. No doubt, in bodies
“ moving in curves round a fixed center, as the centripetal mo-
“ tion increases, the centrifugal one increases likewise; but how
“ this motion which is only generated by the former, should at
“ last get the better of the power which produces it, and that
“ too at the very time that that power has acquired its utmost
“ force and energy, seems somewhat difficult to conceive.—It
“ is the only instance I know, wherein the effect increasing
“ regularly with the cause, at last, while the cause is still acting
“ with its utmost force, the effect entirely gets the better of the
“ cause, and leaves it in the lurch; for the body attracted is
“ at last carried away with infinite velocity from the attracting
“ body. By what power is it carried away? Why, say our phi-
“ losophers, by the very power of this attraction, which has now
“ produced a new power superior to itself, to wit, the centrifugal
“ force. However, perhaps all this may be very reconcileable
“ to reason; far be it from me to presume attacking so glorious
“ a system as that of attraction. The law that the heavenly
“ bodies are said to observe, in describing equal areas in equal
“ times, is supposed to be demonstrated, and by this it would
“ appear, that the centripetal and centrifugal forces alternately
“ get the mastery of one another.

“ HOWEVER, I cannot help thinking it somewhat difficult to
“ conceive, that gravity should always get the better of the cen-
“ trifugal force at the very time that its action is the smallest,
“ when the comet is at its greatest distance from the sun ; and
“ that the centrifugal force should always get the better of gra-
“ vity at the very time that its action is the greatest, when the
“ comet is at its nearest point to the sun.

“ To a common observer, it would rather appear that the sun,
“ like an electric body, after it had once charged the objects
“ that it attracted with its own effluvia or atmosphere, by degrees
“ loses its attraction, and at last even repels them ; and, that the
“ attracting power, like what we behold in electricity, does not
“ return again till the effluvia imbibed from the attracting body
“ is dispelled or dissipated, when it is again attracted ; and so on
“ alternately. For, (at least to an unphilosophical observer) it
“ appears somewhat repugnant to reason, to say, that a body fly-
“ ing off from another body some thousands of miles in a minute,
“ should all the time be violently attracted by that body, and
“ that it is even by virtue of this attraction that it is flying off
“ from it. He would probably ask, what more could it do, pray,
“ were it really repelled ?”

THE kind of bodies, or comets here spoken of by this ingenious Author, he considers as essentially different from the generality of comets mentioned by our astronomers. I before only pointed out what may be called the general path of comets ; but it is evident from the same cause, viz. inequality of power on different sides, their directions may be infinite. The principal difference between the comets here spoken of, and what is generally understood by that term, seems to consist in their not exhibiting the phenomena of tails (instead whereof they are surrounded by a faintish light), and in never becoming visible after their progress towards the sun. Doubtless these bodies are of the same kind with other comets ; for, as the direction wherein the comet shall move is prescribed by that side of the body which emits the largest portion of matter, if this power does not force it so nearly in a direct line to the sun, that his action shall alter the direction of the power, and of course the line the comet moved in, it never can return through the same part of the regions of space, but will be carried onwards into the regions beyond the sun ; and from its extreme velocity, it is not likely would ever more be visible in our hemisphere.

THE danger apprehended by astronomers from comets, does not seem to be entirely without foundation ; for, should one of these bodies, in its progress through the regions of space, strike upon the earth's atmosphere, the percussive arising from the
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extreme velocity of the comet's motion would be so great, that the consequent compression of the atmosphere would diffuse the waters over the highest mountains, and it would be a considerable time after the departure of the comet before the vibration would entirely subside, so as the ebbing and flowing of the waters should as usual be governed by the moon. It is perhaps millions to one that this never will happen; but it is evident the earth has suffered the most violent convulsions from this or some other cause, the irregularities of its surface, as well as the great number of teeth and shells of fishes found upon the tops of high mountains, are indubitable proofs that the parts of the earth have been extremely agitated, and that these eminences have at some period been covered with water.

ACCORDING to the theory here offered, it is evident no bodies are ever attracted and absorbed into the body of the sun to supply him with fresh fuel. Although it seems certain the system will not last to all eternity, yet (as will hereafter be explained) we may pretty safely assert, it will exist through a period of years infinitely beyond our conception.

FIXED STARS. If bodies, as I have asserted, are composed of elastic and nonelastic matter, and that the former, by its natural inherent property, is continually separating from the latter, it is obvious,

obvious, in process of time bodies must decay and be worn out, and new ones formed. This accordingly is observed to be the case; many stars, which in former ages shone with great brilliancy, have entirely disappeared, or lost much of their brightness, and many new ones have shone forth in different parts of the heavens. Lucid spots, cloudy stars, Magellanic clouds, and all the various changes of the celestial bodies, unite to confirm the universality of these properties in matter. But the decay of motion in our system is of the greatest importance, as we are furnished with proofs thereof (if observations are to be depended upon), which cannot be controverted.

FERGUSON, in a note, page 235 of his *Astronomy*, says,
“ There are two ancient eclipses of the moon recorded by
“ PTOLEMY from HIPPARCHUS, which afford an undeniable proof
“ of the moon’s acceleration. The first of these was observed at
“ Babylon, Dec. the 22d, in the year before CHRIST 383, when
“ the moon began to be eclipsed about half an hour before the
“ sun rose, and the eclipse was not over before the moon set;
“ but by most of our astronomical tables, the moon was set at
“ Babylon about half an hour before the eclipse began, in which
“ case there could have been no possibility of observing it.—The
“ second eclipse was observed at Alexandria, Sept. the 22d, the
“ year before CHRIST 201, where the moon rose so much
“ eclipsed,

“ eclipsed, that the eclipse must have begun about half an hour
“ before she rose; whereas, by most of our tables, the beginning
“ of the eclipse was not till about ten minutes after the moon
“ rose at Alexandria. Had this eclipse begun and ended while
“ the sun was below the horizon, we might have imagined, that
“ as the ancients had no certain way of measuring time, they
“ might have been so far mistaken in the hours that we could
“ not have laid any stress on the accounts given by them: but,
“ as in the first eclipse the moon was set, and consequently the
“ sun risen before it was over; and in the second eclipse, the sun
“ was set, and the moon not risen till some time after it began;
“ these are circumstances which the observers could not possibly
“ be mistaken in.”

THE above Author accounts for this acceleration of the moon's motion with the same kind of regard to a connection in his system, as he preserved in accounting for the tide's rising on that side of the earth turned from the moon. He says (in speaking of the planets disturbing one another's motions), page 83, “ That
“ there is reason to believe that the moon is somewhat nearer
“ the earth now than she was formerly; her periodical month
“ being shorter than it was in former ages. For our astrono-
“ mical tables, which in the present age shew the times of solar
“ and lunar eclipses to great precision, do not answer so well for
“ very

“ very ancient eclipses. Hence it appears, that the moon does
“ not move in a medium void of all resistance, § 174; and there-
“ fore her projectile force being a little weakened, whilst there
“ is nothing to diminish her gravity, she must be gradually
“ approaching nearer the earth, describing smaller and smaller
“ circles round it in every revolution, and finishing her period
“ sooner, although her absolute motion with regard to space be
“ not so quick now as it was formerly, and therefore she must
“ come to the earth at last; unless that Being, which gave her
“ sufficient projectile force at the beginning, adds a little more
“ to it in due time.”

I find Mr. FERGUSON (from some calculations, page 90 of his Astronomy) considers the earth's atmosphere to extend to the moon, but that it is 34.193 cyphers thinner than at the earth's surface. From this extreme rarity, he thinks it would not resist the moon's motion so as to be sensible in many ages; but that it might resist her motion to a degree sufficient to account for the above phenomenon. If we grant that the earth attracts the moon, the moon the earth in return; that this attraction is directed to the centers of the bodies, and that this centripetal tendency is balanced by a centrifugal force; in short, that the acceleration of the moon's motion flows naturally from what is called the centripetal and centrifugal laws; I would ask how it

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“ before she rose; whereas, by most of our tables, the beginning
“ of the eclipse was not till about ten minutes after the moon
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“ the sun was below the horizon, we might have imagined, that
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happens that the earth does not complete a revolution round the sun in less time?—For certainly, if such a body as the moon (according to astronomers) without an atmosphere is so sensibly resisted to be determined by observation; the earth with such an atmosphere reaching to the moon, must evidently be considerably resisted in passing through the material rays of light.

BUT, as the idea of the earth with its atmosphere (even if we suppose its atmosphere but fifty miles high) being projected with a velocity of sixty-five thousand miles an hour through the material rays of light, without being thereby in the least impeded, disturbed, or prevented from circulating freely with the earth in its diurnal rotation, is superior to my comprehension, I leave it to those whose subtilty of penetration may be found equal to the task.

THIS acceleration of the moon's motion, and the decay in that of the earth's, may I think be much more rationally accounted for on these principles, than by any law of the Newtonian theory. It has been observed, that the moon's atmosphere is situate nearly at the extremity of the earth's; it has likewise been remarked that this was the cause of her slow motion in her orbit; now it is plain to our senses, that the sun continually discharges a prodigious quantity of matter, and as it is impossible from the nature of this matter

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And ever all return to him again (*e*), it necessarily follows, that his power must be diminished; and since the earth exposes more surface in proportion to her magnitude, she cannot emit so great a proportion of matter, and must therefore gain upon the sun; hereby the earth's atmosphere must be enlarged, extended further on every side, and inclose more of the sun's atmosphere, by which means the earth must act with greater force upon the moon, and thereby accelerate her motion, so that a lunation will be completed in a shorter period. The decay of power in the sun necessarily decreases his motion, and consequently the force of his action upon the earth, which will therefore move proportionally slower, and make our years of greater length.

It may be gathered from the slowness of this decay, that the system will exist several millions of years; for if the sun discharges a thousand millions of tons of matter every second of time, his body is of sufficient bulk to last twenty millions of years.—I have merely stated these observations, to prevent the vulgar or superficial reasoner from drawing false conclusions, by fancying, that from the constant discharge of such a prodigious quantity of matter, a greater decay must arise than is observable from the precession of the equinoxes, &c.

(*e*) A great quantity is compressed by the watery particles of the sun's atmosphere into the form of clouds, which will be constantly expanding again and striking into every direction; so that a very considerable quantity by this means returns again to the body.

S E C T I O N IV.

PHENOMENA OF THE MOON.

TO account for the various anomalies of the moon, has ever been considered as the most difficult part of the science of the celestial bodies; the shifting of the nodes, and the moving of the apogee in contrary directions; her various velocities in different parts of her orbit, and at different seasons of the year; the exhibiting always the same, or nearly the same face, and innumerable other minute irregularities, have been the subject of much trouble and perplexity to the astronomical world.

THESE varied irregularities, these infinite variety of motions, will not, I presume, appear incongruous to this theory; but it must be observed, it is impossible to apply these principles to the solution of the moon's phenomena in so decisive a manner as we could wish, for several reasons. Her anomalies arise from the peculiarity of her situation; that is, to her being exposed to the

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action of two bodies, whose degrees of power must be continually varying;—could we ascertain the exact distance of the sun from the earth, and the exact proportion of his force, we could determine with precision the extent of the earth's atmosphere; and were we also furnished with the exact distance and power of the moon, we could then assert how far she is exposed to the action of the earth, and how far to that of the sun, in every position; but since neither the distance of the sun from the earth, his magnitude, nor the distance of the moon, are ascertained with sufficient accuracy to determine their degrees of power decisively, we must content ourselves with pointing out by what cause the the principle of her irregularities are produced.

PTOLEMY, and most of the ancient astronomers, reckoned the distance of the moon to be 59 of the earth's semidiameters, or 236.000 miles, VANDELIN and HUYGENS 60, COPERNICUS $60\frac{1}{2}$; TYCHO $56\frac{1}{2}$; Sir ISAAC NEWTON is of opinion TYCHO's tables make too great an allowance for refraction, and therefore he places the moon at the distance of 60 of the earth's semidiameters; as the quantity of refraction is so very uncertain, I have taken the mean of these different calculations, and suppose the moon to be $58\frac{1}{2}$ semidiameters, or 234.000 miles from the center of the earth; so that admitting the radius of the earth's atmosphere, (see phenomena of the earth) to be 257.500 miles, and the radius
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of the moon's 37.000; she must be situate partly within, and partly without the earth's atmosphere, as represented fig. 1. plate III. I do not assert this is precisely the place of the moon, it must be determined by nice observations of her phenomena, in the different parts of her orbit (perhaps, by this means, we may be enabled to fix the dimensions and distances of the sun, the earth, and the moon, with a greater degree of exactness than by any method hitherto practised); we may however safely assert she is situate, either as represented fig. 1. or fig. 2.; for, if the power of the sun did not so far interpose as to prevent the earth's atmosphere from entirely closing round that of the moon, or were she situate as represented fig. 3. she would undoubtedly turn upon her axis as the other planets do (*f*), since it is evidently the counteraction of the sun, upon that side of her atmosphere furthest from the earth, which compresses it, and prevents her having such motion: and, it may be further presumed, that this is nearly the true place of the moon from the slowness of her orbicular course, wherein she must be retarded by the action of the sun upon that part of her atmosphere which comes in contact with his.

(*f*) I have no regard in this place to the moon's menstrual motion, by which she may be said to turn on her axis with respect to the sun; but when I say, turn on her axis as the other planets do, I mean that she would, if it was not for her peculiar situation, have a twofold motion, occasioned by the power of the earth, as the earth has by the action of the sun.

THE path the moon describes in revolving round the sun, and round the earth, may be represented by fig. 4. plate III. the line *A B C D E F*, points out so much of the earth's orbit as it passes over during a lunar revolution; and the line *a b c d e f*, the track of the moon during the same period; hence it appears, the moon is carried through twenty times the space by the power of the sun, than by that of the earth, and, as the moon is situate so near the extremity of the earth's atmosphere, this superior power of the sun must have sufficient influence to preserve her at all times nearly in the plane of the ecliptic; and, as the poles of the earth make an angle of $23\frac{1}{2}$ degrees with this plane, the moon must necessarily cross the equator twice in every lunation, and be once at her greatest northern, and once at her greatest southern declination, which is from 28 to 29 degrees.

THE better to explain the cause of the acceleration, and retardation of the moon's motion, see plate III. fig. 5., where the circle *A A A A* represents the equatorial parts of the earth's atmosphere, and *B* the pole thereof; *C* the moon upon the equator, *D* her greatest northern declination, *E* her place crossing the line to the south, and *F* her greatest southern declination.—Now the earth's atmosphere being very nearly spherical, the power at all parts thereof must be nearly the same, and therefore *B*, the pole, being considered as the axis, it is obvious the moon must constantly

constantly describe greater or less arcs, as her declination north or south is more or less; that is, in passing from C to D, her orb is continually contracting, and as regularly dilating from D to E; and in like manner during the other half of the lunation, contracted from E to F, and dilated again from F to C; consequently the moon must go much faster round her center (the earth) in the higher latitudes, than in the low, and this would be uniformly the case, were it not for the fluctuating power of the sun upon her in different situations; for he sometimes adds to her slowest motion, and deducts from her quickest; and at others, adds to her quickest motion, and deducts from her slowest: hence it appears, if the earth's orbit round the sun were perfectly circular, acted upon with a uniform number of impulses, still the varieties of the moon's motions must be almost infinite; need we then wonder that they are so, when there is the greatest reason to presume the orb of the earth is far from a circle? Not that I suppose it is such a figure as the Newtonian doctrine would inculcate (that is, a regular elipsis, with a small motion round the common center of gravity between itself and the moon), but that it puts on such a figure, differing from a circle, as the resistance from the fixed stars is greater or less upon the sun's atmosphere, in the various parts of the earth's annual course. Nice observations upon the difference between true and apparent time will point out those stars from which the sun receives the greatest

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resistance, and by this means we may furnish ourselves with the great outline, viz. the true figure of the earth's orbit; without this, none of our observations can be quite perfect. And although the moon's motions are so very irregular, every person must acknowledge, if the true causes of these varieties are pointed out, we shall be naturally led to the discovery of her true path, but without the help of this knowledge (the time when these motions are nearly repeated are at such distant periods) philosophy would be for ever baffled in its attempts to reduce the moon's phenomena to any regular system.—Fig. 6. plate III. is the same object in a different point of view, and may serve to elucidate more clearly what is meant by the moon's describing lesser arcs at her northern or southern declination, than when upon the equator; the line A A is the radius of the circle she describes when in the former situation, and B B the radius of the circle she describes when in the latter.

SECTION

S E C T I O N V.

THE EBBING AND FLOWING OF THE SEA.

TH E subject of the present Section being a phenomenon wherewith every one is acquainted, its operations being evident to our senses, it deserves to be examined with particular attention; for, as we here know the precise effect, the consistency and justness of the cause assigned may be determined with greater certainty, than upon subjects where the effect as well as the cause are involved in some degree of obscurity.

THE ebbing and flowing of the sea would naturally engage the attention of mankind, whenever the understanding of man was sufficiently cultivated to contemplate the works of nature; the subject was however too abstruse, and it was for a long time considered as one of those occult operations which are performed by the immediate agency of the Almighty. But when it was observed, that the water rose higher at certain times than at

others, and that such higher risings happened at uniform periods, it naturally led them to examine the situation of other bodies, to see how far they might interfere to produce this phenomenon. They quickly discovered, that the rising was greater about the full and change of the moon, than at the first and third quarters, and, that it rose highest of all at the vernal and autumnal equinoxes; hence it was naturally inferred, since the moon in certain situations has the power of altering the degree of ebb and flow, she must certainly be the original cause of this motion of the waters: but in what manner and by what action this was effected, philosophers have not hitherto been able to explain.

IF bodies mutually attract each other, it seems reasonable that the moon, by her attraction, should raise the waters on the side of the earth next her; but the cause of as high rising at the same time on the opposite side, seemed altogether inexplicable by any reasonable hypothesis. At length, however, Mr. FERGUSON with much seeming ingenuity unloosed this intricate knot, and suggested the plausible theory which has been quoted, and sufficiently commented upon in the preceding part of this treatise.

THE rising of the tides has ever been considered as one of the most irrefragable proofs of the existence of attraction, but (as I before observed) if it were really by the *attraction* of the moon that

the waters are raised, why are they not highest immediately under the moon? This question is certainly unanswerable, and when this matter, with the other parts of the phenomenon, are examined without prejudice, certainly I cannot be taxed with presumption for asserting, the moon does not raise the waters on the side of the earth next her by her attraction, nor does the centrifugal force of the earth round the common center between itself and the moon cause the flux thereof on the other.

THE ebbing and flowing of the sea, clearly evince there is a connection between the earth and the moon. Since we find that *attraction* is not the basis of this connection, whence therefore does it arise?—The tides are observed to be highest against land exposed to an open sea, where the waters flow freely, about nine hours before the moon, and about three hours after her; that is, nine hours before the moon comes to, and about three hours after she has passed any given meridian, the rising, if not obstructed, will be at its greatest perpendicular height against the sides of the land.

THE moon being considered at the distance of 234.000 miles from the center of the earth, and the semidiameter of the earth's atmosphere being 257.500 miles, it follows that the moon's atmosphere will extend about $18\frac{1}{2}$ degrees upon the very extremity

of

of the earth's atmosphere; but this may be more familiarly explained by referring to the figure, plate IV. where E represents the earth, M the moon, A A A A the earth's atmosphere, B B B B that of the moon. The earth and its atmosphere are turned round by the power of the sun (as before explained) in 24 hours, but the moon is not impelled in her orbit by one revolution of the earth more than 13 degrees; now, as the distance from the earth to the lower edge of the moon's atmosphere, is less than to the place where the matter emitted from the earth and that emitted by the sun are of equal density; and, as the earth's atmosphere by its diurnal motion is impelled against the atmosphere of the moon with the velocity of 900 miles in a minute, of course the matter of the earth's atmosphere will be compressed in that part immediately between the earth and the moon; and from this extra compression, the nonelastic fluid upon the body E, will be forced from the point *a* towards *b* and *c*; but as the body M passes over the surface of the body E, from *a* towards *c*, the waters will be forced from *c* to some place further on, as at *d*, and the water that was swelled up at C, will, by its tendency to preserve the equilibrium, be found at *e*; so that supposing the earth were entirely covered with water, and every part of the same depth, that is, the surface of the fluid, and the surface of the solid earth every where parallel, the waters would be highest, at any
given

given meridian, about $7\frac{1}{2}$ hours before, and $4\frac{1}{2}$ hours after the moon; but this not being the case, shoals and coasts running in every imaginable direction, a great variety in the times of high water, according to the situation and number of obstructions, must necessarily arise.

If it is a bold shore, the water being obstructed thereby, it must naturally bring on high water much sooner; so that there appears to be a perfect agreement between this theory and the phenomenon; and certainly, if we reflect but a moment, divested of prejudice, the motion that is continued in the sea so long after a gale of wind, will convince us beyond a possibility of doubt that the water is preserved in its spherical form by the pressure of a strong elastic fluid.

THE flux and reflux of the ocean is a very trifling vibration of the prodigious mass of water; it demonstrates, however, that the earth and the moon act upon each other, and proves that it is the interference of the moon's atmosphere destroys the equilibrium. The reason the tides are not so high at the first and third quarters, as at the full or change, is, because at those times the matter from the sun acts at right angles in opposition to the power of the moon: to explain this, suppose that I push with my cane horizontally against an obstacle, it is obvious if a second person
puts

puts his hand on the middle of the cane, and pushes perpendicularly, that my power against the obstacle must be diminished in proportion to the increment of his force; and the reason the tides are highest at the equinoxes, is, because the new and full moon crossing the equator at those times, compresses the atmosphere in a greater degree; for, as I have shewn in the preceding Section, the particles of the earth's atmosphere pass much swifter by the moon when she is upon the equator, than at the more northern or southern parts of her orbit; hence it naturally follows, by this increased compressure of the fluid immediately under the moon, the vibration of the waters on either side will be so much increased.

SECTION

S E C T I O N VI.

A T T R A C T I O N.

THE many and varied opinions respecting ATTRACTION, the word being considered under different acceptations by different writers, renders it necessary to take a short review of the subject as it now stands, for which purpose the following is quoted from what is said under this head by the Author of the new *Cyclopædia*.

“ ATTRACTION, in *Mechanics*, the act of a moving power,
“ whereby a moveable is *drawn* or brought nearer to the
“ mover.

“ AS ACTION and REACTION are always equal, and contrary ;
“ it follows, that, in all *attraction*, the mover is drawn towards
“ the moveable, as much as the moveable towards the mover.

L

“ ATTRACTION,

“ ATTRACTION, or ATTRACTIVE *force*, in the *ancient physics*,
 “ denotes a natural power supposed to be inherent in certain
 “ bodies, whereby they act on other distant bodies, and draw
 “ them towards themselves.

“ THIS the Peripatetics call the *motion of attraction*; and on many
 “ occasions SUCTION; and produce various instances where they
 “ suppose it to obtain.—Thus the air in respiration is taken in, ac-
 “ cording to them, by *attraction of suction*; so is the smoke through
 “ a pipe of tobacco; and the milk out of the mother’s breast:
 “ thus also it is that the blood and humours rise in a cupping-glass,
 “ water in a pump, and smoke in chimnies; so vapours and ex-
 “ halations are attracted by the sun, iron by the magnet, straws
 “ by amber, and electrical bodies, &c. But the later philosophers
 “ generally explode the notion of *attraction*; asserting, that a body
 “ cannot act where it is not; and that all motion is performed
 “ by a mere *impulsion*.—Accordingly, most of the effects which
 “ the ancients attributed to this unknown part of *attraction*, the
 “ moderns have discovered to be owing to more sensible and
 “ obvious causes; particularly the pressure of the AIR. To this
 “ are owing the *phenomena* of inspiration, smoking, sucking, cup-
 “ ping-glasses, pumps, vapours, exhalations, &c.

“ THE

“ THE power opposite to *attraction* is called REPULSION; which
“ is also argued to have some place in natural things.

“ ATTRACTION OR ATTRACTIVE *power*, is more particularly
“ used in the *Newtonian philosophy*, for a power, or principle,
“ whereby all bodies, and the particles of all bodies, mutually
“ tend towards each other.—Or, more justly, *attraction* is the
“ effect of such power, whereby every particle of matter tends
“ towards every other particle.

“ ATTRACTION, its laws, *phenomena*, &c. form the chief subject
“ of Sir ISAAC NEWTON’S philosophy.

“ THE principle of attraction, in the Newtonian sense of it,
“ seems to have been first surmised by COPERNICUS. “ As for
“ gravity,” says COPERNICUS, “ I consider it as nothing more
“ than a certain natural appetite (*appetentia*) that the Creator
“ has impressed upon all the parts of matter in order to their
“ uniting or coalescing into a globular form, for their better
“ preservation; and it is credible that the same power is also in-
“ herent in the sun and moon, and planets, that those bodies
“ may constantly retain that round figure in which we behold
“ them.” And KEPLER calls gravity a corporeal and mutual
“ affection between similar bodies, in order to their union. And

“ he pronounces more positively, that no bodies whatsoever were
“ absolutely light, but only relatively so; and consequently that
“ all matter was subjected to the law of gravitation.

“ THE first in this country who adopted the notion of
“ *attraction* was Dr. GILBERT, in his book *De Magnete*, and
“ the next was the celebrated Lord BACON. In France it was
“ received by FERMAT and ROBERVAL; and in Italy by GALILEO
“ and BORELLI. But till Sir ISAAC NEWTON appeared, this
“ principle was very imperfectly defined and applied.

“ IT must be observed, that though this great Author makes
“ use of the word *attraction* in common with the school philo-
“ sophers; yet he very studiously distinguishes between the
“ ideas.—The ancient *attraction* was supposed a kind of quality
“ inherent in certain bodies themselves, and arising from their
“ particular or specific forms.

“ THE Newtonian *attraction* is a more indefinite principle;
“ denoting, not any particular kind or manner of action, nor
“ the physical cause of such action, but only a tendency in the
“ general, a *conatus accedendi* to whatever cause, physical or meta-
“ physical, such effect be owing; whether to a power inherent in
“ the bodies themselves, or to the impulse of an external agent.

“ ACCORDINGLY,

“ ACCORDINGLY, that Author, in his Philosoph. Nat. Prin. Math. notes, “ That he uses the words *attraction*, *impulse*, and *propension* to the center, indifferently ; and cautions the reader not to imagine, that by *attraction* he expresses the *modus* of the action, or the efficient cause thereof, as if there were any proper powers in the centers, which in reality are only mathematical points ; or, as if centers could attract.” So he “ considers centripetal powers as *attractions* ; though, physically speaking, it were perhaps more just to call them *impulses*.” He adds, “ that what he calls *attraction* may possibly be effected by impulse, though not a common or corporeal impulse ; or after some other manner unknown to us.”

“ ATTRACTION, if considered as a quality arising from the specific forms of bodies, ought, together with sympathy, antipathy, and the whole tribe of occult qualities, to be exploded. But when we have set these aside, there will remain innumerable *phenomena* of nature, and particularly the gravity or weight of bodies, or their tendency to a center, which argue a principle of action seemingly distinct from impulse ; where, at least, there is no sensible impulsion concerned. Nay, what is more, this action differs from all impulsion we know of ; impulse being always found to act in proportion to the surfaces of bodies ; whereas gravity acts according to their solid contents,

“ and

“ and consequently must arise from some cause that penetrates
 “ or pervades the whole substance thereof.—This unknown prin-
 “ ciple, unknown, we mean, in respect to its cause, for its *pheno-*
 “ *mena* and effects are most obvious, with all the species and
 “ modifications thereof, we call *attraction*; which is a general
 “ name under which all mutual tendencies, where no physical
 “ impulse appears, and which cannot therefore be accounted
 “ for from any known laws of nature, may be ranged.

“ AND hence arise divers particular kinds of *attraction*; as,
 “ GRAVITY, MAGNETISM, ELECTRICITY, &c. which are so
 “ many different principles, acting by different laws; and only
 “ agreeing in this, that we do not see any physical causes thereof:
 “ but that, as to our senses, they may really arise from some
 “ power or efficacy in such bodies, whereby they are enabled to
 “ act even upon distant bodies; though our reason absolutely
 “ disallows of any such action.

“ ATTRACTION may be divided, with respect to the law it
 “ observes, into two kinds.—1st. That which extends to a sensible
 “ distance—Such are the *Attraction* of GRAVITY, found in all
 “ bodies; and the *attraction* of MAGNETISM and ELECTRICITY,
 “ found in particular bodies.

“ THE

“ THE *attraction* of GRAVITY, called also by mathematicians
“ the *centripetal force*, is one of the greatest and most universal
“ principles in all nature. We see and feel it operate on bodies
“ near the earth, and find, by observation, that the same power
“ (*i. e.* a power which acts in the same manner and by the same
“ rules, viz. always proportionably to the quantities of matter,
“ and as the squares of the distances reciprocally) does also obtain
“ in the moon, and the other planets primary and secondary, as
“ well as in the comets: and even that this is the very power
“ whereby they are all retained in their orbits, &c. And hence,
“ as gravity is found in all the bodies which come under our
“ observation, it is easily inferred, by one of the settled rules of
“ philosophizing, that it obtains in all others; and as it is found
“ to be as the quantity of matter in each body, it must be in
“ every particle thereof; and hence, every particle in nature is
“ proved to *attract* every other particle, &c.

“ FROM this *attraction* arises all the motion, and consequently
“ all the mutation, in the great world.—By this heavy bodies
“ descend, and light ones ascend; by this projectiles are directed,
“ vapours and exhalations rise, and rains, &c. fall; by this
“ rivers glide, the air presses, the ocean swells, &c. In effect,
“ the motions arising from this principle make the subject of that
“ extensive branch of mathematics, called MECHANICS or
“ STATICS;

“ STATICS; with the parts and appendages thereof, HYDRO-
 “ STATICS, PNEUMATICS.

“ 2d. THAT which does not extend to sensible distances.—Such
 “ is found to obtain in the minute particles whereof bodies are
 “ composed, which attract each other at, or extremely near, the
 “ point of contact, with a force much superior to that of gravity;
 “ but which at any distance from it decreases much faster than
 “ the power of gravity.—This power, a late ingenious Author
 “ chooses to call the *attraction* of COHESION; as being that
 “ whereby the atoms or insensible particles of bodies are united
 “ into sensible masses.

“ THIS latter kind of *attraction* owns Sir ISAAC NEWTON for
 “ its discoverer; as the former does for its improver.—The
 “ laws of motion, percussio, &c. in sensible bodies, under
 “ various circumstances, as falling, projected, &c. ascertained
 “ by the later philosophers, do not reach to those more remote
 “ intestine motions of the component particles of the same bodies,
 “ whereon the changes of the texture, colour, properties, &c.
 “ of the bodies depend: so that our philosophy, if it were only
 “ founded on the principle of gravitation, and carried so far as
 “ that would lead us, would necessarily be very deficient.

“ BUT,

“ BUT, besides the common laws of sensible masses, the
“ minute parts they are composed of are found subject to some
“ others which have been but lately taken notice of, and are
“ even yet very imperfectly known. Sir ISAAC NEWTON,
“ to whose happy penetration we owe the hint, contents himself
“ to establish, that there are such motions in the *minima nature*,
“ and that they flow from certain powers or forces not reducible
“ to any of those in the great world.—In virtue of these powers,
“ he shews, “ That the small particles act on one another, even
“ at a distance; and that many of the *phenomena* of nature are the
“ result thereof. Sensible bodies, we have already observed, act
“ on one another divers ways; and as we thus perceive the
“ tenour and course of nature, it appears highly probable that
“ there may be other powers of the like kind; nature being very
“ uniform and consistent with herself.—Those just mentioned
“ reach to sensible distances, and so have been observed by vulgar
“ eyes; but there may be others which reach to such small
“ distances as have hitherto escaped observation; and it is pro-
“ bable electricity may reach to such distances, even without
“ being excited by friction.”

FROM this review of the subject it appears, that *attraction*,
in the sense of the word used by Sir ISAAC NEWTON and the

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generality

generality of philosophers, is only expressive of an effect, the various phenomena whereof are the result of more primary causes.

SOME of our philosophers, however, maintain the contrary, asserting that attraction and gravity are the first of second causes; whilst other writers, allowing themselves greater latitude, and not choosing to trouble their readers with useless definitions, have made use of the terms indiscriminately, either to express a cause or an effect, as best suited their convenience.

It is much to be lamented that more definite and less exceptionable terms, whose meaning it was impossible should be misunderstood, have not been made use of; if attraction is inherent to matter, if such a property does exist in every particle thereof, then the term is warrantable; but if, on the contrary, the tendency of bodies, and the particles of matter towards each other be effected by some other power, the word *impulse* will equally answer every purpose, and is by no means so exceptionable.

I CONFESS I cannot help thinking there must have been some design in using the words attraction, impulse, or propensity of any sort towards a center, promiscuously and indifferently one for another, notwithstanding Sir ISAAC NEWTON tells us he considers

considers those forces not physically but mathematically. This however is extremely evident (whether Sir ISAAC considered attraction as an effect or a cause) that most of the phenomena of nature are explained by the idea of its being a cause. It is the *attraction* of the sun, counter-acting the projectile force, which produces the circular motions of the planets: it is by *attraction* that magnetical bodies operate on each other; by *attraction* electrical substances, as amber, glass, &c. act on feathers, hair, &c.

Attraction of *gravity*, as an agent which occasions the descent of bodies towards the center of the earth, is unjustly so called, though this species of attraction is very properly distinguished from all other kinds. The operations of magnetical and electrical bodies are easily inferred to be effected by impulse; but the force of gravity being proportionate to the quantity of matter in the gravitating body, must of course act upon every particle thereof; and since impulsive forces can only act upon the superficies of bodies, the aid of some other power is required to account for the phenomena of *gravity*. All bodies near the earth are subject to the laws of gravitation, and our philosophers have endeavoured to prove that the same power obtains in the moon, the planets, and the comets, and that every particle in nature attracts every other particle.

It has been found by experiments, that bodies falling from any small distance towards the center of the earth describe $15 \frac{1}{2}$ Paris feet in one second; this force, say they, decreases in proportion as the squares of the distance increase: assuming these as principles, they endeavour to prove this power is extended to the moon, and that it is the very power whereby she is retained in her orbit.

BUT a phenomena, which till of late escaped the observation of the philosophical world, throws a new light upon this subject, proving that gravity is a more innate operation, and not the effect of any attractive property lodged in particles of matter of which the earth is composed. I allude to this well-known fact, that if two bodies of similar diameters, but of different densities, are projected with equal force, the heaviest body will fly farther than the light one; *e.gr.* suppose two cannons loaded with a ball each whose superficies are equal, but the one specifically as heavy again as the other, are discharged with the same force of powder, the heaviest ball will be projected to considerably the greatest distance: This circumstance attentively considered, will be found absolutely to demonstrate that the whole force of gravity, when a body is projected horizontally above a certain degree of velocity, is not directed towards the center of the earth; that the earth does not *attract* bodies in proportion to their quantity of matter, and of course

course that every particle in nature does not *attract* every other particle. Perhaps it may be urged, the resistance of the air occasions the earlier descent of the light body; but as the atmosphere can only press upon the surfaces which are equal, it is impossible that should be the case. I know there is a power which is considered by philosophers as the cause of this phenomenon, viz. that tendency which bodies have to persevere in motion; this I consent is the true cause, but we shall shew in the ensuing theory of gravity, that this *vis* is a natural consequence depending upon a mechanical agent.

It is a rule in this philosophy, that the quantity of matter emitted by any inferior body, is prescribed by the quantity emitted by the superior; and therefore the expansive or elastic force of any body must be proportionate to its magnitude: or in other words, if in a certain quantity of space are situate a certain number of bodies, issuing matter into this space (*g*), and if this matter, from its inherent property, expands into every direction, it is plain, that one body emitting a thousand, or a million times as much matter as another, will engross a thousand or a million times as much space; of course the inferior body must be content with such portion as its power shall enable it to occupy (in this light

(*g*) In this case we are not to consider the space void, but as filled with a fine elastic medium of one universal density.

is to be understood what is expressed by the sizes of the atmospheres of the planets, and of the superior prescribing the power of inferior bodies). From these premises we deduce, that all bodies projected into the earth's atmosphere do not contain a sufficiency of matter, and of course expose too much surface to be able to support themselves; what then must be their destiny? simply—they must fall. That this power, which may with propriety be called *vis motrix*, is one of the great principles of gravity, is evident from the disposition of bodies in an exhausted receiver.

THE inclination observable in all bodies of falling towards the center of the earth, is one of the most difficult and abstruse phenomenon in the whole circle of nature's operations; yet doubtless, if she acts by certain immutable, mechanical laws, this also may be explained if we can attain a complete knowledge of the primary qualities of matter: indeed the whole phenomena of motion are so intimately connected, that if we can trace out by what means nature performs any one of these motions, we shall be furnished with the cause, or causes, whereby she effects the whole. Just ideas of the expansive properties of matter, is the chief principle to the understanding of this subject: for the active particles emitted from any body expanding and filling all the surrounding space, and flying with such inconceivable rapidity, when
they

they meet with particles of a similar magnitude issued by another body, must be resisted (*b*); this resistance produces a reaction on the medium through which they have passed; and this reaction upon all sides must compress the remaining mass into a sphere, and from the same principle all small bodies are forced towards the center thereof: those watery passive particles, which by the force of the active particles are carried from the surface of the body, are by this means compressed, forming such a medium as that which surrounds the earth, most dense at the surface, and continually increasing in rarity, as the distance from the body increases; the resistance the matter from the earth meets with from the sun's atmosphere must communicate motion to the whole, and this motion answers to the circular rotation of the earth and its atmosphere, whereof all bodies situate therein must necessarily partake.—This constant reaction preserves all bodies

(*b*) The fine elastic particles of matter do not seem to resist each other in any considerable degree, but at those parts where they meet with others of equal density. That matter flies with such amazing rapidity, is gathered from the velocity of the particles of light or matter from the sun; and to keep nature to her simplicity, we must suppose the matter emitted from the earth to have the same progressive motion, and that its velocity increases in proportion to its distance and rarity. Light (according to astronomers) comes from the sun in $8\frac{1}{4}$ minutes; therefore it moves at the rate of 164,000 miles in a second; and as it must increase in velocity (agreeable to this notion of general expansion) as it recedes from the body, it must have come more than 164,000 miles the last second. Considering these things under this idea, it is obvious, the particles issued from the earth will have acquired a very great degree of velocity at the distance of 257,000 miles, the semidiameter of the earth's atmosphere.

close

close against the surface ; for it is evident, any substance lying upon the surface of the earth, if it weighed one hundred pounds, would remain at rest, were the central power or force of reaction equal only to one pound, and if such body is attempted to be moved, the attempt must be resisted with its whole weight, for the reason already explained, that it cannot support itself : hence we are furnished with the great outline of gravity, the descent of all bodies being occasioned by the united efforts of these two powers : *the vis motrix, or power of falling, because the body does not contain a sufficiency of matter to support itself ; and the reactive force, which necessarily impels all substances towards the center of the earth.*

SOME may find a difficulty in comprehending the nature of action and reaction upon which the several phenomena of the universe depend : for instance, it might plausibly enough be asserted, that if the reactive force is one of the causes of the descent of bodies, it must be more powerful than the power which gives birth to it, viz. the emission of the active particles ; otherwise this power, being strongest, would carry off all bodies :—but it must be observed, the particles of matter when first emitted from the earth, are in a state which differs much from those which compose the air or medium which surrounds the surface ; in the former case they are inconceivably minute, and so extremely compressed

as to pass through substances without communicating any or very little momentum; (this will appear obvious to any one who will observe the operations of the magnetic and electric matter). Perhaps this idea may be rendered more familiar by referring to plate VI. fig. 1. where the circle, of which A is the center, represents the earth, B any certain quantity of corpuscles emitted therefrom, and C a body projected into the atmosphere: these corpuscles we know, from a variety of experiments, pass through substances without communicating (as before observed) any momentum; and if, when they arrive at the extremity of the earth's atmosphere, as at D, they are resisted by the matter from the sun, and divided into perhaps a hundred times the number of particles, so highly expanded as to occupy a thousand times as much space as they filled at their first emission from the earth, it is evident they must compress the particles which compose the medium immediately in contact with them, and as this medium is continued to the surface of the body A, this compression or reaction thereof must extend thither likewise, and must therefore press upon the upper surface of the corpuscles of which the body C is composed, by this means propelling it towards the center of the earth. That such a constant pressure of the atmosphere is equal to this effect, is extremely evident from the resistance it gives to projectiles, which of late has been discovered to be inconceivably great. But these powers, it must be observed, could

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not

not exist without the passive matter, or watery particles, which prevent the elastic corpuscles from expanding so much near the surface of the earth, as they do at greater distances.

HAVING now explained what I conceive to be the cause of reaction, we return to the main subject, *gravity*. The proportionate forces of the *vis motrix*, and the central or reactive power upon falling bodies, is always the same ; but the resistance of the air, which must be likewise considered in the phenomena of gravity, so varies the descent of bodies, that the degrees thereof cannot be easily reduced to any general rules, and therefore adds much to the abstruseness of the laws observed by falling bodies. The resistance bodies meet with in their passage through the air is proportionate to the velocity with which they move, as well as to their forms, and quantities of surface ; although I have not been able to ascertain its power of retardation upon substances of different forms, and moving with different velocities, yet I am convinced by many repeated experiments, it is infinitely superior to the proportion Sir ISAAC NEWTON has stated. Had I leisure and opportunity to make nice experiments, I could have offered a more determinate, demonstrable theory of the various specific gravity of bodies, more worthy the attention of philosophers than the loose desultory one here laid down ; but as I am not

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furnished

furnished with these necessary materials, I shall only add a few words by way of illustrating the positions already advanced.

SUPPOSE a body is projected into the atmosphere, what are the forces acting upon such body? *First*, the power which projected it, or the projectile force. *Second*, the resistance of the air. *Third*, the central, or reactive force. And *Fourth*, the *vis motrix*, or power of falling.

If a body is projected perpendicularly, there are two powers counteracting the projectile force, viz. the resistance of the air, and the central power; at a certain height, these powers will be in equilibrio, that is, the counteraction of the two powers is become equal to the force of the projectile; the body, now suspended in mid-air, being acted upon by the fourth power, or *vis motrix*, must of necessity *fall*, and towards the center of the earth, because the central or reactive force prescribes that direction: the power of the projectile being now annihilated, the reactive force acts in conjunction with the *vis motrix*, and from the united action of these two powers perpetually acting arises the accelerating force of gravity; but the resisting medium, as it before opposed the ascent, now opposes the descent of the body, deducting from its weight in proportion to its surface, form, and velocity.

UPON these grounds, we easily explain that property in bodies called by our philosophers *the power of persevering in motion*; for, if a body of any given magnitude, not sufficiently large to support itself, *must fall*, and has the same tendency to proceed in any direction, that power which acts upon it with the greatest force must prescribe the direction in which it shall persevere.—Thus when a body is moved by any impulse, as the action of gunpowder, &c. with a greater degree of velocity than such body would describe in descending from any given height by the force of the central power only, then would this *vis motrix*, this tendency of persevering in motion, or of falling into any direction, act with the projectile; and its power being always proportionate to the quantity of matter in the moving body, it is a necessary consequence, that if two cannon balls of similar magnitudes, but of dissimilar densities, are projected with equal force, the heavier will persevere in the motion communicated longer than the light one.

WE find, from our senses, that matter continually issues from the sun, and by experiments we can prove, that precisely the same species of matter continually issues from the earth; now if there is any analogy between the heavenly bodies, the rest of the planets do so likewise; and if so, it is evident the sun must prescribe the quantity of matter issued by each, and the limits of their
atmospheres;

atmospheres; if these premises are admitted, the preceding theory of gravity is undoubtedly just, and therefore the power all small bodies (we make our experiments upon) have of moving, and the cause of their remaining at rest, proceeds from the causes here laid down, viz. the *vis motrix*, from the bodies not containing sufficient quantity of matter to support themselves, and the cause of rest from the united action of the *vis motrix* and the central or reactive force. However paradoxical it may appear, that the cause of a body's motion shall be the very cause of its remaining at rest, it is undoubtedly true with respect to all small bodies; but it must be observed, this rest is only relative rest, arising from the intervention of the surface of the earth, which stops the progressive descent of all small bodies. Every phenomena in the universe proclaims there is no such a thing as absolute rest; and therefore relative rest must proceed from motion, and motion from some inherent property stamp'd upon matter by the all-powerful CREATOR.—That GOD does conduct the operations of nature by second causes is no new opinion. “Certain it is”, says LORD BACON, “that GOD worketh nothing “in nature but by *second causes*: and if they would have it otherwise believed it is mere imposture, as it were in favour towards “GOD, and nothing else but to offer to the Author of truth the “unclean sacrifice of a lye.” But the Rev. Mr. JONES's reasoning upon this subject is too strong and conclusive to be omitted.

“ THAT

“ THAT GOD does, in many cases, govern the world by
“ material agents, and conserve the motion of bodies by the
“ activity of secondary causes, is beyond dispute. The support
“ of animal life by breath; the motion of a ship before the wind;
“ of the sap in vegetables at the approach of the sun’s light; of
“ the mercury in the barometer by the pressure of air; of the
“ fluid in the thermometer by the expanding power of fire;
“ of bodies impelled and driven off again by the flux and reflux
“ of the electrical æther, with innumerable other phenomena of
“ nature, all conspire to establish this plain truth. And if it be
“ an axiom in physics, that more causes are not employed where
“ fewer will suffice, how comes it to pass that those agents,
“ which confessedly minister to so many and great effects, are
“ not sufficient for the producing of all? Shall we allow that
“ God governs the world by a subordinate agency and mechanism
“ in some cases, where that agency appears to us, and deny it
“ in others, merely because we have lost sight of it, or because
“ it would make against us? A philosophy that labours under
“ this difficulty, and is one while working with a material cause,
“ and in the next breath with an immaterial one, be it ever so
“ ingeniously put together, will after all be liable to this grand
“ exception; at best it is inconsistent and unworthy of God.
“ Every body must see and know that there are material causes
“ acting in the world; and he that denies it must deny his
“ senses:

“ senses: if these causes are not sufficient to perform all the
“ stated operations of nature, then the CREATOR hath made use
“ of such means as are not proportionable to the end. If
“ the CREATOR himself performs them by the immediate agen-
“ cy of his own substance, then is there no need of any other
“ causes; they are all superfluous. But that there are other
“ causes is abundantly evident; therefore they must be capable
“ of answering their end, and every material effect will be imme-
“ diately owing to a material cause. What I here say is grounded
“ upon this reasonable postulatum, if it may not rather be called
“ an axiom, That the wisdom of God is consistent with itself in
“ its operations; and that he wants neither power nor skill to
“ avoid the error of inconsistency: grant but this, and the argu-
“ ment amounts to demonstration.” JONES’S First Prin. Nat.
Philos. p. 30.

WE now proceed to the phenomena of MAGNETISM,
upon which subject it is hoped the ideas laid down in
the preceding part of this treatise may throw considerable
light. Many ingenious hypotheses have been offered to
explain the operations of magnetical bodies; by some it is
supposed, the earth is hollow and contains a nucleus in its cen-
ter, surrounded by a fluid medium; and that agreeable to the
direction of this nucleus, the needle is turned to or from the
pole.

pole. Others affirm, there are several distinct loadstones situate in different parts of the earth, which of course attract the needle as their vicinity renders them most powerful. A third opinion maintains, that a fine subtle effluvia is continually passing from pole to pole, which effluvia passing through the pores of the needle, communicates the polar direction. The two former opinions seem almost exploded, and in answer to the latter, if the matter passes from pole to pole, how comes it that the variation is sometimes twenty, thirty, nay even fifty degrees?

It will readily be granted, that fine subtle particles of matter are constantly issuing from the body of the earth;—now, if certain substances conduct this matter better than others, the particles will pass through those substances; so that a body of this kind being suspended in such a manner as to vibrate freely, will assume and point the direction in which the matter passes. It is obvious too, that if these fine elastic particles are not issued from every part of the surface in similar quantities, the particles will (from their inherent property of expansion) direct themselves towards those places whence fewest are emitted: thus if a certain part, in a south-east direction from any other given part, does not emit the elastic particles so plentifully, those emitted at the latter will direct themselves towards the former place; the magnetic needle, when suspended horizontally, will assume a

South-east direction, and the dipping-needle will make a greater or less angle, as the matter passes more or less obliquely. That the matter emitted from the earth must react equally on every part is evident, since at the extremity of the earth's atmosphere the particles must in all places be of similar density; for, although the same proportionate quantity is not every where emitted, yet the matter, as before observed, from its inherent property will pass from the denser towards the rarer parts, so that at some considerable distance from the surface, the surrounding medium must be in the same state. Now as the atmosphere, from this equality of the reactive power, presses equally on every side, it follows, that great varieties must arise in quantities of elastic matter issued from different portions of the earth, since wherever more surface is exposed to the pressure of the atmosphere, fewer particles will have power to fly off: hence it is obvious, a much smaller quantity will be emitted from the sides of hills and rising grounds than from low flat even surfaces. From these premises we conclude, there must be a great variety in the portions of matter emitted by different parts of the earth; and if, from any of the above causes, there is a general deficiency for any considerable space, the particles from the surrounding parts will tend thereto, and of course the suspended needle (as the matter passes most freely through it) will point in that direction, and the dipping-needle will mark its obliquity: when the matter passes off in perpendicular lines, the

dipping-needle will point to the zenith, and the horizontal needle will not stand in any particular direction; this, I need not observe, is the case in some parts of the globe.

It seems very plain that the matter passes *from* the earth through rods of iron or steel, because such rods continuing for any considerable time in a perpendicular position acquire the magnetic property, and will, when suspended, point out the direction of the matter; this has been imagined to arise from some power pulling the end of the rod downwards; but does it not appear more reasonable, since steel is known to be a better conductor than any other substance, that the matter passes from the earth into the suspended rod, and out at the ends, because there it meets with the least resistance; and a greater quantity from the south end than from the north, because that end of the rod having stood upwards, the pores are naturally disposed for the more easy admission of the matter? It is worthy remark, that when suspended horizontally, this end will be elevated, and it is farther observable, this end, which points towards the zenith, is much stronger than the other: these are demonstrative proofs that more matter issues thence, and that it arises *from* the earth.

THE process of making magnets, being an incontrovertible proof of the matter's issuing from the earth, is here subjoined as

laid down by the ingenious Mr. CANTON. “ Procure a dozen
“ bars, six of soft steel, each to be three inches long, one quarter
“ of an inch broad, and one twentieth of an inch thick ; with two
“ pieces of iron, each half the length of one of the bars, but of
“ the same breadth and thickness ; also six pieces of hard steel,
“ each five inches and an half long, half an inch broad, and three
“ twentieths of an inch thick ; with two pieces of iron of half the
“ length, but the whole breadth and thickness of one of the hard
“ bars ; and let all the bars be marked with a line quite round
“ them at one end. Then take an iron poker and tongs, or two
“ bars of iron, the longer they are and the longer they have been
“ used the better ; and fixing the poker upright between the
“ knees, hold to it, near the top, one of the soft bars (having its
“ marked end downwards) by a piece of sewing silk, which must be
“ pulled tight by the left hand, that the bar may not slide ; then
“ grasping the tongs with the right hand a little below the middle,
“ and holding them nearly in a vertical position, let the bar be
“ stroked by the lower end from the bottom to the top, about ten
“ times on each side, which will give it a magnetic power suffi-
“ cient to lift a small key at the marked end ; which end, if the
“ bar was suspended on a point, would turn towards the north,
“ and is therefore called the north pole, and the unmarked end is
“ for the same reason called the south pole. Four of the soft
“ bars being impregnated after this manner, lay the two parallel

“ to each other, at the distance of one fourth of an inch, between
“ the two pieces of iron belonging to them, a north and a south
“ pole against each piece of iron; then take two of the four bars
“ already made magnetical and place them together, so as to
“ make a double bar in thickness, the north pole of one even
“ with the south pole of the other; and the remaining two being
“ put to these, one on each side, so as to have two north and two
“ south poles together; separate the north from the south poles
“ at one end by a large pin, and place them perpendicularly with
“ that end downwards on the middle of one of the parallel bars,
“ the two north poles towards its south, and the two south poles
“ towards its north end; slide them backward and forward three
“ or four times the whole length of the bar, and removing them
“ from the middle of this, place them on the middle of the other
“ bar, as before directed, and go over that in the same manner;
“ then turn both the bars the other side upwards, and repeat the
“ former operation: this being done, take the two from between
“ the pieces of iron, and placing the two outermost of the touch-
“ ing bars in their room, let the other two be the outermost of
“ the four to touch these with; and this process being repeated
“ till each pair of bars have been touched three or four times
“ over, which will give them a considerable magnetic power;
“ put the half dozen together after the manner of the four, and
“ touch with them two pair of the hard bars placed between their

“ irons, at the distance of about half an inch from each other ;
“ then lay the soft bars aside, and with the four hard ones let
“ the other two be impregnated, holding the touching bars apart
“ at the lower end near two tenths of an inch, to which distance
“ let them be separated after they are set on the parallel bar, and
“ brought together again before they are taken off : this being
“ observed, proceed according to the method described above,
“ till each pair have been touched two or three times over.
“ But as this vertical way of touching a bar will not give it quite
“ so much of the magnetical virtue as it will receive, let each
“ pair be now touched once or twice over in their parallel posi-
“ tion between the irons, with two of the bars held horizontally,
“ or nearly so, by drawing at the same time the north of one
“ from the middle over the south end, and the south of the
“ other from the middle over the north end of a parallel bar ;
“ then bringing them to the middle again, without touching the
“ parallel bar, give three or four of these horizontal strokes to
“ each side. The horizontal touch after the vertical, will make
“ the bars as strong as they possibly can be made, as appears by
“ their not receiving any additional strength when the vertical
“ touch is given by a greater number of bars, and the horizontal
“ by those of a superior magnetic power. This whole process
“ may be gone through in about half an hour ; and each of the
“ large bars, if well hardened, may be made to lift twenty-eight
“ Troy

“ Troy ounces, and sometimes more. And when these bars are thus
“ impregnated, they will give to an hard bar of the same size its
“ full virtue in less than two minutes ; and therefore will answer
“ all the purposes of magnetism in navigation and experimental
“ philosophy much better than the loadstone, which is known
“ not to have a sufficient power to impregnate hard bars. The
“ half dozen being put into a case, in such a manner as that two
“ poles of the same dimensions may not be together, and their
“ irons with them as one bar, they will retain the virtue they
“ have received ; but if their power should, by making experi-
“ ments, be ever so impaired, it may be restored without any
“ foreign assistance in a few minutes. And if, out of curiosity, a
“ much larger set of bars should be required, these will commu-
“ nicate to them a sufficient power to proceed with, and they
“ may in a short time by the same method be brought to their
“ full strength.”

WE observe in this process, that the end which is held upwards
in preparing the bar, when the bar is so suspended as to swing
freely, always endeavours to be elevated ; this undoubtedly de-
notes that the matter comes from the earth.

WE come next to treat of that property in magnetic bodies
by which they act on each other : these motions agree with the
same

same phenomenon we find in electricity; in fine, all motion, as things are at present situated, must spring from that elastic property we find in the active part of matter; but as bodies differ considerably in their proportionate quantities of active and passive matter, as well as the active matter being of different degrees of elasticity, certainly some bodies must be better disposed to let the active matter pass through them than others; and such substances only exhibit these appearances, which, by admitting this fine subtile matter to pass through them with superior facility, emit a more than ordinary quantity. Two magnets laid on a table covered with a piece of white paper, then a few steel filings scattered around them, will very nicely distinguish how the matter operates on applying the two north or south ends towards each other: by noting the disposition of the filings, it plainly appears the matter issues from them in such quantity as to force off the atmosphere, which is of course pressing continually on the atmospheres of the magnets on all sides, the quantity of matter issued from each being equal, the particles are of the same density; hence it is very natural to expect a resistance to take place, and if we observe the meeting of the filings in the intermediate space, the cause of these bodies repelling each other is extremely obvious, as we there see the resistance marked out with great accuracy. Let a north and a south end be placed in a similar manner, and the filings scattered as before, we shall find the
filings

filings very differently disposed; in this case we see no mark of any resistance between the magnets, so that we must suppose (the south end being the strongest) that the matter from the south end of one magnet enters the north end of the other, owing, I imagine, to its meeting less resistance in passing that way than into the air: since this appears to be the case, the cause of these bodies uniting is evidently owing to the uniform pressure of the atmosphere.

HENCE we may gather the laws observed by magnetic bodies, viz. when the particles emitted from each resist each other more than they are resisted by the surrounding medium, then the bodies recede from each other; but when the particles from the bodies resist each other less than they are resisted by the adjoining medium, then they are impelled together.

It has been urged that the motion of magnetic bodies cannot be an effect proceeding from an impulse without, because magnets act in the same manner under an exhausted receiver; this however is drawing the conclusion too precipitately, for it is well known that this fine effluvia passes as freely through glass as if no such substance intervened; so that the atmospheres of the magnets being acted upon the same as before, no difference can arise between the phenomenon, in such a vacuum, and in the open space.

space. It seems confirmed on all hands, that the emitting of equal quantities of matter by two bodies is the cause of their repelling, and of unequal quantities the cause of their uniting; thus two bodies in a positive state of electricity recede from each other, and so likewise two bodies in a negative state. The south ends of magnets opposed to each other, repel; so do the north; and *vice versa*, a positive and a negative, a north and a south unite.

ELECTRICITY. I shall not enter into a long detail of the minutiae of this subject, it will be sufficient to examine the principles upon which the science (for so it is called) is founded. The Author of Cyclopædia, under the article Theory of Electricity, says, "In the more advanced state of *electricity*, there have
 " been two principal theories, each of which has had its advocates.
 " The first we shall mention is that of two distinct electric fluids,
 " repulsive with respect to themselves, and attractive of one
 " another, adopted by Mr. DU FAY, on discovering the two
 " opposite species of *electricity*, viz. the vitreous and the resinous,
 " and since new modelled by Mr. SYMMER. These two fluids
 " are supposed to be equally attracted by all bodies, and to
 " exist in intimate union in their pores; and in this state to
 " exhibit no mark of their existence. The friction of an electric
 " by a rubber separates these fluids, and causes the vitreous
 " *electricity* of the rubber to pass to the electric, and then to the

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“ prime conductor of a machine, and the resinous *electricity* of
“ the conductor and electric to be conveyed to the rubber; and
“ thus the quality of the electric fluid possessed by the conductor
“ and the rubber is changed, but the quantity remains the same in
“ each. In this state of separation, the two electric fluids will
“ exert their respective powers; and any number of bodies
“ charged with either of them will repel each other, attract those
“ bodies that have less of each particular fluid than themselves,
“ and be still more attracted by bodies that are wholly destitute
“ of it, or that are loaded with the contrary. According to this
“ theory, the electric spark makes a double current, one fluid
“ passing to an electrified conductor from any substance presented
“ to it, whilst the same quantity of the other fluid passes from it;
“ and when each body receives its natural quantity of both fluids,
“ the balance of the two powers is restored, and both bodies are
“ unelectrified. Thus also when a phial is charged by a con-
“ ductor, the resinous *electricity* of that side which is connected
“ with the conductor is transmitted to the opposite side connected
“ with the rubber, and an equal quantity of the vitreous *electricity*
“ is returned from this side to the other; so that all the vitreous
“ *electricity* is conveyed to one of the sides, and all the resinous
“ to the other. In this state they mutually attract each other
“ through the substance of the intervening glass, are thus pre-
“ vented from being drawn away by any force that can be applied
“ to

“ to them separately, and rush to one another by means of proper
“ conductors.” The other theory he states, “ Is commonly
“ distinguished under the denomination of *positive and negative*
“ *electricity*, and was first suggested by Dr. WATSON, and digested,
“ illustrated, and confirmed by Dr. FRANKLIN; and has been
“ since known by the appellation of the Franklinian hypothesis.
“ This theory supposes, “ That all the phenomena of electricity
“ depend on one fluid *sui generis*, extremely subtle and elastic,
“ dispersed through the pores of all bodies, by which the par-
“ ticles of it are as strongly attracted as they are repelled by one
“ another. When bodies possess their natural share of this
“ fluid, or such quantity as they are capable of retaining by their
“ own attraction, they are then said to be in an unelectrified
“ state; but if the equilibrium is disturbed, and they either
“ acquire an additional quantity *from* other bodies, or lose part
“ of their natural share by communication *to* other bodies, they
“ exhibit electrical appearances. In the former case they are said
“ to be electrified positively, or *plus*; and in the latter negatively,
“ or *minus*.” This elastic fluid is, according to my ideas, one of the
principles of which all bodies are composed, which must necessarily
operate, as it is observed to do, throughout the whole circle of
electrical experiments.—Positive electrics are bodies composed of
a very large portion of highly elastic active matter; and it is evi-
dent such bodies must be least porous, because the particles having

so strong an inclination to separate, when in a state of fusion, react with proportionate strength, of course forming very close masses with extreme minute pores. Negative electrics are bodies composed of a larger portion of watery inelastic particles, which being incompressible and inert, will not suffer the elastic matter to exert itself without a much greater degree of friction; but even from these substances electric matter may be extracted, for wood, &c. when violently rubbed will produce fire. That the electric matter is a fluid, extremely subtle and elastic, is I think too obvious to be doubted; from these plain facts, where nature evidently acts by the most simple laws, have I drawn my opinions of the mode the great DESIGNER and CREATOR of the universe has chosen to effect the various operations thereof. The term attraction is used to express that effect excited bodies are observed to have upon light substances; this has been already shewn (speaking of magnetic attraction) to arise from an outward impulse or pressure of the atmosphere: the use of this word to express a cause, or inherent property in bodies, is, in my opinion, a material objection to the present theory of electricity, and I am persuaded the expulsion of this term would tend much to the advancement of true physical knowledge.

COHESION. To understand the phenomena of *cohesion*, nothing more seems necessary than to conceive aright the properties of
active

active and passive matter, and the manner in which these qualities operate under different circumstances.

“ How, and by what principle these several and distinct corpuscles should come first joined and combined into little systems, and how they should come to persevere in that state of union, is a point of the most difficulty, and even of the most importance of any in physics.” *Cyclop. Art. Coh.*

SIR ISAAC NEWTON'S doctrine of cohesion is, that “ The particles of all hard homogeneous bodies, which touch one another, cohere with a great force; to account for which, some philosophers have recourse to a kind of hooked atoms; which, in effect, is nothing else but to beg the thing in question. Others imagine, that the particles of bodies are connected by rest, *i. e.* in effect, by nothing at all: and others by conspiring motions, *i. e.* by a relative rest among themselves. For myself, it rather appears to me, that the particles of bodies cohere by an attractive force, whereby they tend mutually towards each other: which force in the very point of contact is very great; at little distances is less, and at a little further distance is quite insensible.” May I, without offence to the admirers of this great man, ask, how much more to the purpose is it to assert, that
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the particles of bodies cohere by an *attractive force*, than to say such effect is produced by a kind of *hooked atoms*?

THE cohesion of atoms or primitive particles, of which the celestial bodies are composed, and why in spherical forms, has already been shewn to arise from the reaction of matter, which is a necessary consequence in elastic fluids that expand and are resisted. This theory, upon the extensive scale of the universe, holds equally good when applied to the cohesion of the particles of small bodies, which are preserved in a solid state by the constant uniform reaction or pressure of the atmosphere; so that we have a perfect idea of the most minute phenomenon by referring to this great outline, or the continual expansion and consequent reaction of the active part of matter, regulated by the inelastic, passive, watery particles, which are the great bond of union.—They who imagine the watery particles are not competent to this great purpose of regulating the expansive force of the elastic particles, let me ask them by what means water extinguishes fire? I presume no one will deny but that this is effected by compression; so that here we have a very familiar idea of the action of these two fluids on each other; and if reason has any place in philosophy, it is reasonable to suppose that an
incompressible

incompressible fluid is the best calculated to adjust the expansive force of the compressible (*i*).

To melt or reduce metals to a fluid state, a very strong degree of heat or motion of elastic particles is necessary; and a substance whilst melting, or in a state of fusion, is surrounded by a strong atmosphere of elastic matter, which prevents the watery particles in the air from pressing upon it: this will appear by holding the hand near the metal, when the extreme rapid motion of the particles will be very perceptible. It is worthy remark, that the metal will continue in a fluid state after being taken off the fire, till the motion of its particles has in some degree subsided, and the watery particles in the common atmosphere have sufficient power to introduce themselves, and mix with the melted fluid (*k*). Hence it seems obvious the watery particles, joined with the elastic, form solid bodies; and the elastic particles, by passing through the interstices of the nonelastic, preserve them in a fluid state: hence too we perceive why water becomes frozen, viz.

(*i*) According to Sir ISAAC NEWTON, where the attracting power ceases, there does a repelling power commence. These strange properties given to matter is, by this philosophy, explained simply thus: when the inert incompressible particles, by the uniform pressure of the atmosphere, are too powerful for the elastic or compressible ones, then will the particles of any body remain in contact; but when the elastic expansive matter is most powerful, the particles necessarily recede from each other.

(*k*) That the watery particles are equal to this effect is obvious, or why does the immersing a piece of red hot steel in water fix its particles so compactly? Can we deny that this is performed by the incompressibility of the water? or is it by attraction?

when

when there is not a sufficient motion of the elastic particles, the inelastic, by the uniform pressure or reaction of the atmosphere, adhere together.

BUT there is a natural phenomenon which places these matters in a still clearer point of view, *i. e.* volcanos; how do the advocates of the proposition, That every particle in nature attracts every other particle, account for these notorious operations? Do they not act diametrically opposite to, and positively contradict such an idea? If our prejudices have not absolutely blinded us, and chained our reason, we shall no longer support this theory of universal attraction, but shall be judicious enough to adopt more rational notions.

ALL mountains of any considerable height, and that terminate in a point, either are or have been volcanos; there may indeed be some exceptions to this general rule, but be assured, if such mountain terminates in an immediate point, it is composed of matter that has an extraordinary share of watery inelastic particles, otherwise it would burn like other mountains: the reason is obvious, the higher the barometer is elevated above the general surface of the earth, the lower the mercury therein descends, consequently the pressure of the atmosphere decreases in a similar proportion; now the point of the mountain exposing less surface,

(and the quantity of watery particles in the atmosphere, as well as its pressure, being also much less upon that than upon any other part) the expansive force of the elastic matter will be sufficiently powerful to break through the surface; and when this operation is once performed, it will constantly continue emitting, because the watery particles in the surrounding atmosphere cannot be sufficient to counteract its force, till a long series of years shall have exhausted the matter contained within side the mountain.—

Plate V. fig. 1. will explain this and other phenomena of volcanos more familiarly, A A A A represents a mountain, B B B the direction of the matter; for as it is continually issuing out of the mouth of the crater, it will as constantly tend thitherwards from all the internal parts, naturally endeavouring to preserve the equilibrium; the consequence of this must be a general intestine motion for several miles, which forming an almost inexhaustible quantity of matter, it seems reasonable that a mountain shall continue to burn for ages.—This uniform convergency of the matter towards the crater, or point, because it there meets with the least resistance, necessarily leaves the sides of the mountains destitute, and furnishes us with the reason why the sides of these mountains are perpetually covered with ice and snow, viz. because there is not a sufficiency of elastic matter to pass through and fluiditate these inelastic particles. Matter will continue to issue from the top of the mountain, till such time as the pressure of the

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atmosphere

atmosphere (or reaction of the matter upon the watery particles) shall be sufficiently powerful to counteract its force; but then the mountain will have lost so much matter, and will expose so much surface, that very little will be able to issue: hence it follows, the mountain under these circumstances will be as intensely cold as before. There is another more general cause why mountains of all descriptions are colder than the level parts of the earth, viz. the medium or atmosphere being denser at the lower than at the upper parts of the mountain, of course at the lower parts there is a greater number of inelastic particles, which refracting and reflecting the rays of the sun, cause a vibrating motion of the parts, which produce heat.—It is observable, that the matter frequently bursts from the sides of these mountains; this can only happen to a mountain that is considerably reduced, and the shell become very weak, and then when the matter, by some accidental cause, being accumulated in a larger than ordinary portion in the internal part (or perhaps the mouth of the crater stopped by the falling in of ice, snow, &c.), bursts through this thin shell, and forms as it were a new distinct crater.

SECTION

S E C T I O N VII.

REFLECTION OF LIGHT. THE FORMATION OF CLOUDS. LIGHTNING.
WATER-SPOUTS. LIGHT AND HEAT.

IT is not consistent with my plan to enter into a minute investigation of these several subjects. I shall only say a few words upon each, tending to shew that these appearances are not incompatible to, but perfectly corresponding with the principles I have been endeavouring to inculcate.

THE laws of REFLECTION have never been ascertained, nor its various phenomena accounted for under the idea of attraction; from the foregoing theory, however, it is hoped some information may be derived.

If the atmosphere is considerably replete with watery particles suspended by the elastic matter, the rays of light from the sun running in straight lines through this atmosphere, must be impeded

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by

by these incompressible impenetrable particles, and be inclined or forced back, that is, reflected, as they shall happen to strike upon the spherules of water in an inclined or parallel direction: to exemplify this, suppose plate V. fig. 2. represents a certain quantity of rays or particles of light passing through the atmosphere; those which are obstructed by the watery particles will be directed this way and that way, from one to another, as shewn in the figure. By this means bodies are illuminated on every side; but if the rays of light were not reflected by the watery particles, that side of bodies at any time furthest from the sun would be totally dark; this also would be our situation when any cloud, loaded with a sufficiency of watery particles wholly to intercept the rays, intervened; and it is evident the light at such times is derived from reflection, because it is uniformly diffused and illuminates all sides of bodies alike.

THIS theory might be demonstrated, and the various degrees of light and shade reduced to mathematical laws, by supposing the rays of light possessed of a certain velocity, the force lost by their percussion against the particles of water equal to such a ratio, &c.; but these nice demonstrations do not to me, I confess, appear of any great utility.

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THE FORMATION OF CLOUDS may, I presume, be considered as a proof that matter is endued with the properties, and operates in the manner here proposed. Without action, or the continual issuing of elastic matter from the earth, there could be no ascent of vapours, or passive watery particles; and without reaction these particles could not be compressed and formed into an atmosphere; and without certain bounds, or places where the matter emitted by the earth is resisted, there could be no reaction.

THE Newtonian philosophy supposes the compression of the atmosphere arises from the gravity of its particles; but how then are these particles supported and prevented from descending and uniting to the surface of the earth? Nor does it appear less a paradox to our understandings to comprehend, why the attraction, which is the cause of this gravity, does not wholly prevent the separation and ascent of any matter from the surface. These doctrines are, however, endeavoured to be explained, and the property observable in certain parts of matter endeavoured to be accounted for, by asserting, that where an attractive power ends, there does a repelling power take place; which is seeming to infer that matter is endued with a soul or thinking faculty, and that its operations are voluntary. I cannot, however, help observing, that by this assertion the learned Author contradicts himself; for, laying down the
axioms

axioms or laws of motion, he says, "That all matter is inert, " indifferent either to a state of rest or motion."

LIGHTNING proceeds from a compression of the elastic matter by the inelastic, being generally produced by the junction of clouds forced together by the motion of the air, hereby of course a very large portion both of active and passive matter is accumulated, but by their union the elastic particles contained in each becoming too powerful for the government of the nonelastic matter, immediately discharge themselves into that direction which is most open to receive them, or, which is the same thing, contains the fewest watery particles. If there happen to be clouds above, which contain a considerable quantity of inelastic matter, or the active particles force themselves out at the lower side of the united clouds, they will necessarily dart downwards.—A cloud of this sort may not unaptly be compared to a number of electric sparks, for the elastic matter must be surrounded with the watery particles, and when they break through the surface occasion the sound of thunder.

It has been the subject of much dispute whether a pointed rod, or one headed with a ball was the best calculated for the safety of a building against lightning. A point exposes very little surface, consequently the reaction or pressure of the atmosphere is very trifling

trifling upon such part of a body, of course considerably more of the elastic matter, which is ever passing through all bodies, will issue from the point than from any other part; by this means the watery particles in the surrounding atmosphere are forced off to a considerable distance; now, if the lightning in its descent comes within the sphere of the point's action, the particles thereof will immediately converge towards it; because the elastic particles are easily compressed, and afford an easy passage to the descending matter: hence we see why a pointed rod receives the lightning and leads it off better than one headed with a ball, viz. because the sphere of the action of the former extends to a much greater distance than that of the latter. See this delineated in plate V. fig. 3.

WATER-SPOUTS. The first appearance of this phenomenon is in form of a deep cloud, the upper part whereof is white, the lower black; from the lower part hangs, or rather falls down what is called the spout, in manner of a conical tube, biggest at the top; under the tube is always observable a violent emotion and flying up of the water, like a column, or pillar, some yards above the surface of the sea.

Now, whether is it more reasonable to suppose that the cloud contains more matter than the body of the earth, and therefore

attracts the water (for otherwise if every particle in nature attracts every other particle, it is inconceivable how the cloud could draw up the water by its superior attraction); or that the cloud putting on this figure, does in some degree prevent the reaction or pressure of the atmosphere upon the part immediately under it? grant but this, and the mystery of water-spouts is very easily explained; for if the reaction be diminished, the action must be proportionally increased, or the equilibrium could not be preserved; but as the elastic matter in the earth will in such cases always act instantaneously and with an irresistible force, if the pressure is considerably lessened, no wonder the water is forced up in the manner observed in this phenomenon.

LIGHT *and* HEAT seem to spring from one and the same cause, which I define to be the motion of the fine active particles of matter; but our sight being a much more refined susceptible sensation than our feeling, we can perceive light when there is not a sufficient quantity of motion to affect us with heat.—Bodies are said to be light, or dark; as these however are only comparative terms, a substance naturally light may be dark in comparison of one extremely luminous; thus the sun is said to be lucid, the moon and the planets opaque; but that this arises only from the great disproportion in the quantities of matter emitted by each will not appear at all improbable when the immense difference in
point

point of magnitude is considered, and when it has been shewn by calculation that the sun emits eight thousand three hundred and thirty millions of times as much matter as the moon does.—The elastic matter is LIGHT and HEAT itself, and always produces similar effects when the quantity and velocity of its motion is sufficient: the particles from the sun, which striking upon the sides of the moon's atmosphere opposite to him, by the velocity they have acquired pass through it in straight lines (which is always the case, when the medium through which the rays are passing is denser than the particles whereof they are composed), and meeting with the incompressible, impenetrable particles upon and near the surface of the moon, are reflected thence in every direction, and of course afford light to the earth, but not in quantity sufficiently large to produce heat.

IN the former part of this treatise I promised, that the non-existence of a vacuum (or in other words, that the celestial space cannot be either a perfect void, or so near such a state, as must of necessity be the case were the world governed and the planets conserved in their orbits and motions by the laws which Sir ISAAC NEWTON and his followers have endeavoured to establish) should be proved by incontrovertible evidence. The eclipses of the sun and moon were the objects then in view, and certainly

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from

from these phenomena may be deduced, **without** the possibility of deception, this plain fact, *That the space between the earth and the moon is replete with matter, denser than the surrounding expanse filled by the particles emitted from the sun.* A figure may perhaps elucidate the matter more clearly to some of my readers; see plate VI. fig. 2. where E represents the earth, the small space *a a* between the circles its supposed atmosphere, and M the moon, in their true proportions; now if A A A be a vacuum, how is the elastic matter B B B B (which comes from the sun) prevented from diffusing itself into and filling up the vacuum? It is very easy to say that the particles naturally move in straight lines; but by what we know of the properties of elastic matter, it immediately pervades all space that is not occupied by a fluid denser than itself: thus the elastic matter in an exhausted receiver diffuses itself into every direction, though this same matter, when passing through a dense medium flies swiftly forward in a straight line.—However difficult it may be to form just notions of the progressive motion of light, it is evident the particles do not move in straight lines but when the medium through which they are passing is denser than themselves. The matter in the blaze of a candle is in a confused intestine motion, acting every way; but at any small distance, where the surrounding medium is denser than the particles emitted by the burning taper, it is obvious they

they fly in straight lines, because any intervening body produces a shadow. Just so must it be with the particles from the sun ; were not the space between the earth and the moon already filled with matter, the particles would close round the earth, and no eclipse could possibly be produced.

THE CAUSE OF MOTION

It is a common notion that motion is caused by a force. But what is a force? Is it a push or a pull? Or is it something else? The answer to these questions is not so simple as it seems. In fact, the cause of motion is a very complex matter, and one that has puzzled philosophers and scientists for centuries.

THE CAUSE OF MOTION

S E C T I O N VIII.

ON THE VIS INERTIÆ OF MATTER. THE PATH OF PROJECTILES, &c.

“ DEFINITION III.

“ *T*H E vis insita, or innate force of matter, is a power of resisting,
“ by which every body as much as in it lies endeavours to persevere
“ in its present state, whether it be of rest or of moving uniformly for-
“ ward in a right line.

“ T H I S force is ever proportionate to the body whose force it
“ is, and differs nothing from the inactivity of the mass but in
“ our manner of conceiving it. A body, from the inactivity of
“ matter, is not without difficulty put out of its state of rest or
“ motion; upon which account, this *vis insita* may by a most
“ significant name be called *vis inertiae*, or force of inactivity.—
“ But a body exerts this force only when another force impressed
“ upon it endeavours to change its condition; and the exercise
“ of

“ of this force may be considered both as resistance and impulse:
 “ it is resistance, in so far as the body for maintaining its present
 “ state withstands the force impressed; it is impulse, in so far as
 “ the body, by not easily giving way to the impressed force of
 “ another, endeavours to change the state of that other. Resist-
 “ ance is usually ascribed to bodies at rest, and impulse to those
 “ in motion: but motion and rest, as commonly conceived, are
 “ only relatively distinguished; nor are those bodies always truly
 “ at rest which commonly are taken to be so.

“ DEFINITION IV.

“ *An impressed force is an action exerted upon a body in order to*
 “ *change its state either of rest, or of moving uniformly forward in a*
 “ *right line.*

“ THIS force consists in the action only, and remains no
 “ longer in the body when the action is over. For a body main-
 “ tains every new state it acquires by its *vis inertiae* only. Im-
 “ pressed forces are of different origins; as, from percussion,
 “ from pressure, from centripetal force.” SIR ISAAC NEWTON'S
 Math. Prin. vol. I. p. 3.

FROM

FROM this and some other parts of Sir ISAAC's doctrine, it appears that matter has a power of moving, a power of remaining at rest, a power of attracting, and a power of repelling.—Now I am inclined to believe, that some of these powers owe their existence in philosophy to the power of Sir ISAAC's inventive genius: his not knowing the cause why all small bodies should have a power of persevering in motion, he concluded that it was an *innate vis* in bodies independent of any cause, or that it was a primary quality in matter. As the learned Author fancied this power independent of a cause, with the same warmth of imagination he created a power in body, by the exercise of which it remained at rest; so that by the force of those powers all bodies resisted every new change. This was to be sure a very ready way of philosophizing (to give matter what properties we please), as it preserves an advantage peculiar to itself; for if we can but once perform the act of deglutition, the mathematics is a never-failing digester. But I think we never can pretend to say, that there is to be found such a property in bodies as an *innate vis* of remaining at rest; for certain it is that the following experiment demonstrates that no such power has existence:

TAKE two bodies of equal magnitude, the one of wood, the other of iron, let them be turned as perfectly round as possible, and as perfectly polished: when they are thus prepared, lay them

on

on a smooth surface, such as a fine polished marble, looking-glass, or a piece of ice. Now, if the bodies have any innate power of persevering in that state you put them in, it will here discover itself; for if it does exist, it must be in every particle of which the bodies are composed; and as we have no other way of knowing the quantity of matter in a body but by its specific gravity, we must conclude, if one body is to the other as 12 to 1 (let the *vis inertiae* be in what proportion to gravity it may), that it should require twelve times the force to move the ball of iron as to move the ball of wood: *e. gr.* suppose the ball of iron to weigh twelve pounds, the ball of wood one pound; now, say that the *vis inertiae* in the ball of wood is equal to any stated quantity, suppose we say an ounce, or suppose we say the whole resistance given to the power employed to move the body arises from the *vis inertiae* in the body (instead of the inequalities of the surfaces); then, if the force required to move the ball of wood be equal to one ounce, the force necessary to move the ball of iron should be equal to twelve ounces. But unfortunately for the advocates of this doctrine, we find the resistance of the ball of iron not one *fourth part* of the twelve ounces—where then is the *vis inertiae*? At the same time that we have here a demonstration that bodies have no power stamp'd on them by the CREATOR, by the force of which they maintain every new state acquired, we have a further confirmation of that property in bodies which has been so

strenuously contended for in the preceding part of this work, viz. *of persevering in motion in every direction*; for if those balls are bowled on the surface of the ice with the same degree of force, it will require *much more power* to stop the iron ball than to stop the wood. Now, why are we to support these opinions of inertness, attraction, &c.? Is it because we have so many ingenious mathematical demonstrations of these powers? Of what use is a demonstration of a power that never existed but in the fancy of an ingenious mind? Or is it from a weakness of faith that we cannot credit the existence of a DEITY, without having it mathematically demonstrated? Certainly there can be no danger of encouraging Atheism by allowing active principles in matter; as in the first place, nine tenths of the world never think; and secondly, those that do, never can be so lost as to conceive it a jumble of atoms without design, as there are legible characters of the profoundest wisdom.

THE PATH OF PROJECTILES. The line described by the flight of a projectile serves to explain the property of the medium that surrounds the earth. GALILEO, after him his disciple TORRECELLI, considered the curve described by a projectile to be very near a parabola; these ingenious men were followed in opinion by Mr. ANDERSON, Mons. BLONDEL, Dr. HALLEY, Sir ISAAC NEWTON, &c. Indeed Sir ISAAC observes, that the resistance of the air is too sensible to be neglected.

IN vol. II. book iii. page 230, we find the quantity of resistance, according to this Author, given to all globes, how great so ever, and moved with whatever velocity,

“ That the motions of the planets in the heavens may subsist an exceeding long time.

“ IN the scholium of prop. 40, book ii. I have shewed that a
 “ globe of water frozen into ice, and moving freely in our air, in
 “ the mean time that it would describe the length of its semidia-
 “ meter, would lose by the resistance of the air $\frac{1}{4586}$ part of its mo-
 “ tion ; and the same proportion holds nearly in all globes, how
 “ great soever, and moved with whatever velocity.” But from a
 great number of experiments made with cannon balls, it is found
 that the learned Author was greatly mistaken, in supposing that the
 proportion held nearly in all globes, how great soever, and moved
 with whatever velocity ; since we find that the resistance occa-
 sioned by elastic mediums, the cause why gravity acts in propor-
 tion to the quantity of matter in the body was so little known,
 we need not wonder that the path of a projectile was so ill de-
 scribed. Plate VI. fig. 3. points out the difference between the
 theory of the mathematician and practice : A A A is the line de-
 scribed by the former, and B B B that of the latter, the dotted
 line the plane of the horizon. From this we learn, although the
 power of gravity is so considerable, yet the resisting medium
 under

under certain circumstances even exceeds that power: plate VI. fig. 4. may throw some light upon the cause. Suppose the ball E to be a body projected from a cannon in a horizontal direction; the number of powers acting on this body are five; *first*, the impulse from the cannon which acts at A; *secondly*, the central or reactive force at B; *thirdly*, the resistance of the air at C; *fourthly*, a resistance from the medium being more compressed at D than at C, owing to the surface of the earth; *fifthly*, the *vis motrix* or power of persevering in motion in any direction; this power may be considered in the center at E, so that it will always act with that force that carries the body through the greatest quantity of space. Now, the resistance being much more from D to C, than from C to B, when this power (from the violent motion of the ball compressing the elastic medium) exceeds the central power B, the ball must necessarily rise above the level of the piece. That this will be the case, when the ball is projected with considerable velocity, I am perfectly satisfied; as I find from some experiments made with a lath, the resistance of the air, when bodies are forced through it with a considerable velocity, increase in a very high proportion. A further motion necessarily results from the action of these powers; the power on the body at D and C exceeding the power from C to B, the body consequently turns swiftly round from C to D, &c. but this is not the only cause why those bodies should have such a motion, for the inequalities of their surfaces will produce such an effect.

I AM happy to find the ingenious Author of the new *Cyclopædia* takes particular notice of the phenomenon of a large ball flying further than a small one; as such authority may probably engage the learned world to examine how far the fact is reconcileable to the principles of this philosophy, more especially as our ingenious neighbours the French have, by experiments, undeniably proved the existence of a power which produces this effect. The passage relating to this subject in the *Cyclopædia* will be found under the article gunnery. “ The advantage of large *guns* or cannon over those
“ of a smaller bore is generally acknowledged. This advantage,
“ says Mr. ROBINS, arises from several circumstances, particularly
“ in distant cannonading. The distance to which large bullets fly
“ with the same proportion of powder, exceeds the flight of the
“ smaller ones almost in proportion to their diameters; so that a
“ thirty-two pound shot, for instance, being somewhat more than
“ six inches in diameter, and a nine pound shot but four inches,
“ the thirty-two pound shot will fly near half as far again as the
“ nine pounds, if both pieces are so elevated as to range to the
“ farthest distance possible. The reason of this is the extreme
“ great resistance of the air, which is such, that the distances to
“ which bullets fly is more regulated by this resistance, than by
“ the velocity they receive from the powder, and the larger
“ bullets are less resisted in proportion to their weight than the
“ smaller; so that their respective ranges are found to be nearly
“ in the proportion of their diameters.

“ THIS

“ THIS advantage in the range of the heavier bullet will not
 “ be easily counterbalanced by increasing the charge of powder
 “ allotted for the small bullet. For though the swiftness of this
 “ last, at its issuing from the piece may be thereby greatly in-
 “ creased, yet the distance to which the bullet will fly is thereby
 “ but little influenced; as all this increase of velocity is soon
 “ taken away by the resistance of air, which increases much faster.
 “ This assertion might seem a paradox, but it is irrefragably
 “ established by some experiments made by the French.”

ALL this is certainly contradictory to the generally received opinion of gravity, which, whether it was supposed to proceed from some power in the earth pulling bodies towards its center, or from an *innate vis* in bodies themselves, or from the pressure of an external agent, was always considered under every circumstance, whether at rest upon the surface, or in motion through the air, as acting in proportion to the quantity of matter, or specific weight of bodies; since, however, these stubborn facts absolutely prove the contrary, we should be judicious enough to let them take place of an opinion only superficially framed, from observing that a cubical inch of lead was heavier than a cubical inch of cork, as well with our antipodes as with us.

A SYSTEM of physics must be liable to many objections that does not equally apply to the solution of all the celestial motions; the conjunction which will shortly take place between jupiter and saturn is well worthy the attention of philosophers, and affords ground for nice speculation.—It does not appear from my calculation of the sizes of their atmospheres, that they will come quite in contact, but it is very possible the powers and distances whereon these calculations are founded may not be quite correct; so that I think it extremely probable their atmospheres may interfere with each other, and if so, the motions both of saturn and jupiter upon their axes must be impeded, and by consequence the revolutions of their satellites must be proportionally slower; and it is obvious their nearest satellites will be more sensibly affected on this occasion (if the principles here laid down are just) than if the motions of these planets are regulated by the centripetal and centrifugal laws (*l*).

QUERY. Is it not from sirius that the sun meets the greatest resistance? Is not the vicinity of this body the grand cause of all the motion in our system? Is not this idea supported by the earth being found nearest the sun (when between those two bodies) as from the nature of compression this would be an inevitable consequence?

(*l*) The figure, plate VII. represents the earth and its atmosphere in true proportion, with the atmosphere replete with watery particles.

S E C T I O N IX.

S U M M A R Y.

IN vol. I. Fugitive Pieces, published I believe by Dr. JOHNSON, is a paper entitled, A Review of Four Letters from Sir ISAAC NEWTON to Dr. BENTLY, containing some arguments in proof of a DEITY.

THESE letters, coming from the pen of this great man, contain very interesting matter, I shall content myself with transcribing the first. “ As to your first query, it seems to me that if the
“ matter of our sun and planets, and all the matter in the uni-
“ verse, were evenly scattered throughout all the heavens, and
“ every particle had an innate gravity towards all the rest, and
“ the whole space throughout which this matter was scattered
“ was but finite; the matter on the outside of this space would
“ by its gravity tend towards all the matter on the inside, and by
“ consequence fall down into the middle of the whole space, and
“ there.

“ there compose one great spherical mass. But if the matter was
 “ evenly diffused throughout an infinite space, it would never
 “ convene into one mass; but some of it would convene into one
 “ mass and some into another, so as to make an infinite number
 “ of great masses, scattered at great distances from one to another
 “ throughout all that infinite space. And thus might the sun and
 “ fixed stars be formed, supposing the matter were of a lucid na-
 “ ture. But how the matter should divide itself into two sorts,
 “ and that part of it which is fit to compose a shining body
 “ should fall down into one mass and make a sun, and the rest
 “ which is fit to compose an opaque body should coalesce, not
 “ into one great body, like the shining matter, but into many
 “ little ones; or if the sun at first were an opaque body like the
 “ planets, or the planets lucid bodies like the sun, how he alone
 “ should be changed into a shining body, whilst they all continue
 “ opaque, or all they be changed into opaque ones, whilst he re-
 “ mains unchanged, I do not think more explicable by mere natural
 “ causes, but am forced to ascribe it to the counsel and contriv-
 “ ance of a voluntary agent.” The difficulty Sir ISAAC here la-
 bours under, respecting the lucidity and opacity of the heavenly
 bodies, would have been easily removed, had he been fortunate
 enough to have conceived just ideas of the simplicity and uni-
 formity of nature; that is, had he conceived the sun and planets
 were all composed of similar materials, all acting in the same
 manner,

manner, and by the same laws, viz. the elastic particles continually forcing from each body, through the interstices of the nonelastic matter surrounding their surfaces. Had he considered the subject under this idea, he would not have been at a loss to know why the sun appears lucid, and the planets opaque; nor would he have hesitated a moment to declare, why the sun produces so much more heat than any other body; he would have informed us, that light and heat arose from the same cause; and therefore that the sun appears more luminous, and furnishes a greater quantity of heat, by the same rule that a large fire appears brighter, and communicates a larger portion of warmth than a small one; which is obviously owing to the superior quantity, as well as the increased velocity of the elastic particles. He would have considered the sun to have had a prodigious atmosphere, formed of the watery particles forced up by the action, and compressed by the reaction of his elastic matter: deducing hence, that the temperature of the sun is very different to the superficial ideas we have formed thereof, and that it is, in all probability, as properly adapted for the reception of inhabitants as this terraqueous globe of ours, or any of the other planets. He would have ridiculed the idea, that the comparative brightness observable in the moon during a total eclipse proceeds from the refraction of a few scattered rays, but would have derived it from the natural quantity of matter issuing from her body. He would have explained also,

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why

why the sun and stars are fixed, and would have pointed out the signs, the constellations, nay, even the very stars whereby the sun is most resisted; pursuing the idea, he would have traced the motion of the earth in her orb, and shewn the cause of true and apparent time. Having delineated this irregular track, he would have proceeded to fix precisely the aphelion, and perihelion of the other planets; and have noticed how jupiter affects the motion of saturn and his satellites, and how saturn affects jupiter and his attendants in return. He would have elucidated and proved these various positions mathematically, shewing that the various phenomena of nature are the effect of a certain mechanical agent acting by contact, and without the assistance of any intermediate messengers to veer and haul the halyards of attraction.—The Cartesians would have been convinced by his reasoning, that the hypothesis of vortices was inconsistent; they would have been satisfied that no first motion, in the manner suggested by their leader, is sufficient to keep up that constant action observed throughout the universe, but would had recourse to a continued succession of impulses, proceeding from the various bodies, those great inexhaustible repositories of matter.

TO CONCLUDE, let us take a comparative view of the Newtonian theory and that which is now offered.—Sir ISAAC avers, the various phenomena of the heavenly bodies are produced by
attraction,

attraction, that every particle in nature is attracted by every other particle; hence another consequence, that all matter must be homogeneous, possessed of similar properties, and acting by one universal law.—Were this the case, can we conceive there could be any such thing in the universe as loco-motion? Would not all matter coalesce and form into distinct bodies, and when once settled, for ever remain so without the least alteration? It is true, if we suppose the body of the sun attracts the bodies of the various planets, that these planets were first projected or put in motion by the arm of the ALMIGHTY, we can readily enough conceive they would revolve round him in circular orbs; but, if every particle in nature attracts every other particle, how is it possible the sun should emit rays of light or matter? Would not his attraction, instead of producing such effect, prevent the possibility of any such action? From this, as well as numerous other phenomena of the heavenly bodies, it is demonstrated, that every particle in nature is not homogeneous, does not attract every other particle. But descend to the minute world; observe the various phenomena which every where offer themselves to the examination of our senses, and we shall be possessed, if possible, of still more indubitable proofs that matter is not homogeneous; that there is not in nature any such property as attraction. It may be urged, That I have been endeavouring to refute positions which philosophers never maintained, for they never supposed the sun

to be formed of such matter as the earth and the planets are. How inconsistent is this, if the foundation of the doctrine of attraction and gravity be drawn from the power the earth has (in their own words) of attracting all small bodies towards its center; must not the sun be composed of similar materials, to be possessed of the same properties? To assert the one without allowing the other, is a palpable absurdity.

ACCORDING to the principles here laid down, all bodies are compounded of similar matter, but of two distinct heterogeneous sorts, viz. active, elastic, and passive, inert particles. I need not adduce any proofs that elastic matter (disguised under whatever name of ancient or modern invention or application, whether *pneuma*, fine subtle *æther*, electric fluid, *phlogiston*, &c. &c. for I do not hesitate to assert that these are all one and the same, though perhaps these terms, if properly defined, might be used to express its different modifications) is an universal principle; we can extract it from every substance; and the rays of matter from the sun are precisely the same: but, to produce such action and those appearances we observe in the sun, it is necessary that another species of matter be added, which, by its passivity, counteracts the otherwise destructive power of this active principle; the body of the sun cannot be composed of this elastic species of matter only, since without the passive matter the expansive particles could not
be

be kept together, but would diffuse and spread over the whole space; hence we are furnished with evidence, if we may be allowed to reason from analogy, that the sun and the earth are bodies composed of similar properties; and by the same mode of reasoning we infer, that all the other planets, satellites, comets, and fixed stars, are precisely of the same description. Now, if all the heavenly bodies are homogeneous to each other, but heterogeneous in themselves, it follows, all must act in the same manner and by the same laws; the most general whereof is the continual emission of elastic matter, which at certain distances from each body will be resisted, viz. where the particles emitted by the surrounding or the prescribing body are of similar density, and there may the confines of its atmosphere or power be placed. It is evident the particles of elastic matter do resist each other, from a great variety of experiments, but it is more particularly proved, that this resistance takes place when the particles are of similar density, by applying the two north or two south ends of magnets towards each other, or two bodies in a positive or negative state of electricity; the particles of matter issuing from each, being of the same density, resist each other's progress, and impel the bodies backward.

Thus nature explains herself, and clearly points out the laws whereby she performs her operations; and these laws, taking her phenomena

phenomena collectively, or examining any minute appearance, will furnish us with a consistent explanation thereof; that is, the effect will be found such as these laws must necessarily occasion: for instance, if all the heavenly bodies are formed upon these principles, their action upon each other must be such as nature does actually produce; hereby we conceive how the sun is supported, and why he turns upon his axis: the annular and diurnal revolutions of the planets are consequent of this motion, and in like manner the satellites are governed by the same action of their primaries. Is not the slow motion of the moon in her orbit round the earth, her fixidity upon her axis, and her innumerable irregularities, the necessary effect of her peculiar situation? Does not the rapid velocity with which jupiter turns upon his axis arise from his magnitude and distance from the sun? Does not this theory explain the phenomena of comets, simply and rationally? Is not their peculiar mode of action the inevitable consequence of their inequality of power on different sides? Is not the ebbing and flowing of the sea a necessary effect of the compression of the earth's atmosphere by the intervention of the moon? Are not the abstruse phenomena of attractions, of gravity (or the falling of bodies), of magnetism, of electricity, of cohesion, of volcanos, &c. consequent operations of the action and reaction of matter, regulated by the passive principle? Does not the phenomena of reflection, the formation of the clouds, lightning, water-

water-spouts, light and heat, &c. prove that matter is endued with these properties? that these are its inherent laws, stamped thereon by the wisdom of the DEITY, when his power first called it into existence? If these are not the laws of nature, that is, if the elastic matter is not continually passing through the interstices of the nonelastic, tell me why the pacific ocean, at any small depth, is not one solid rigid mass of ice?

THE END.

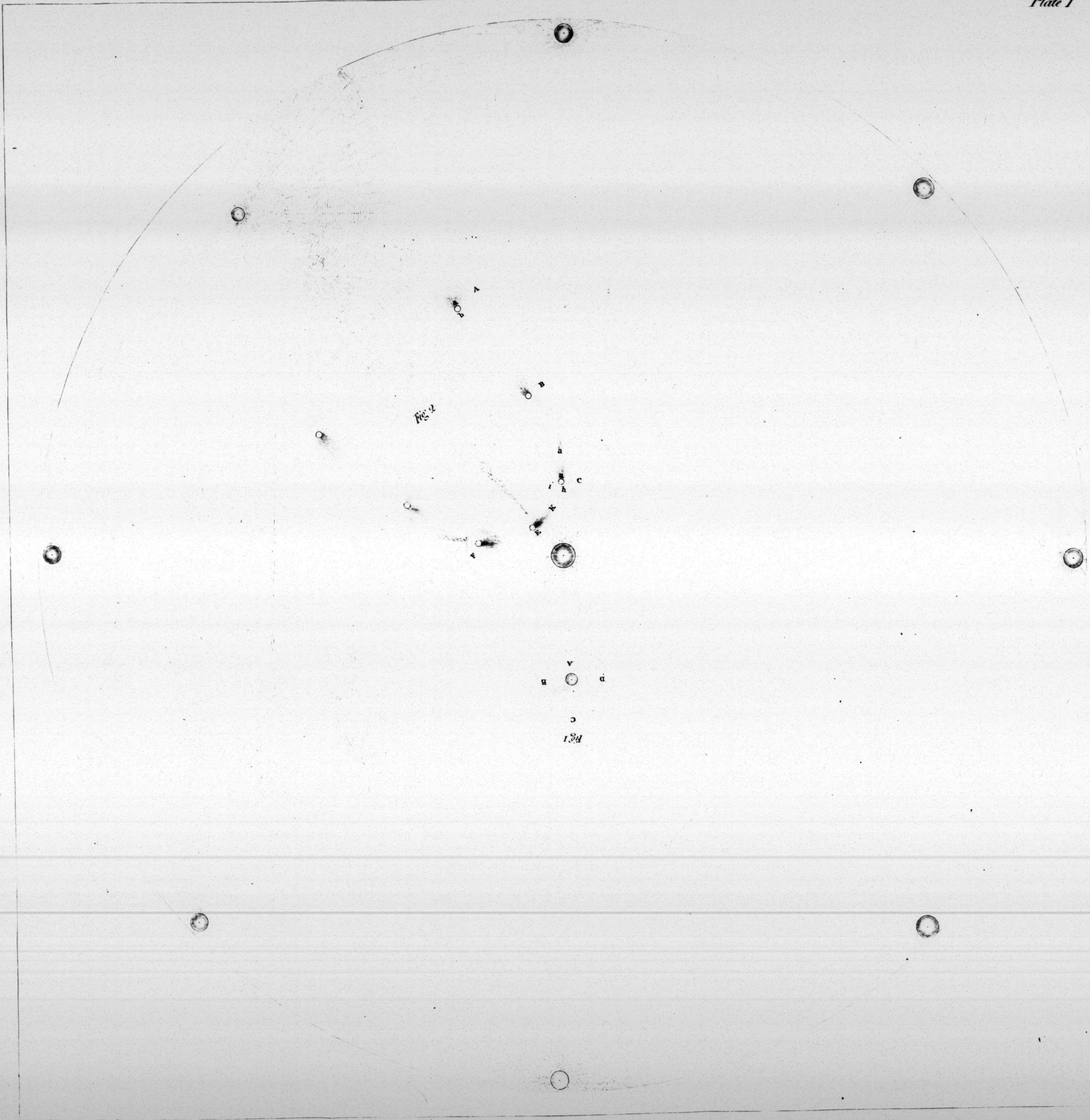




Fig. 1st

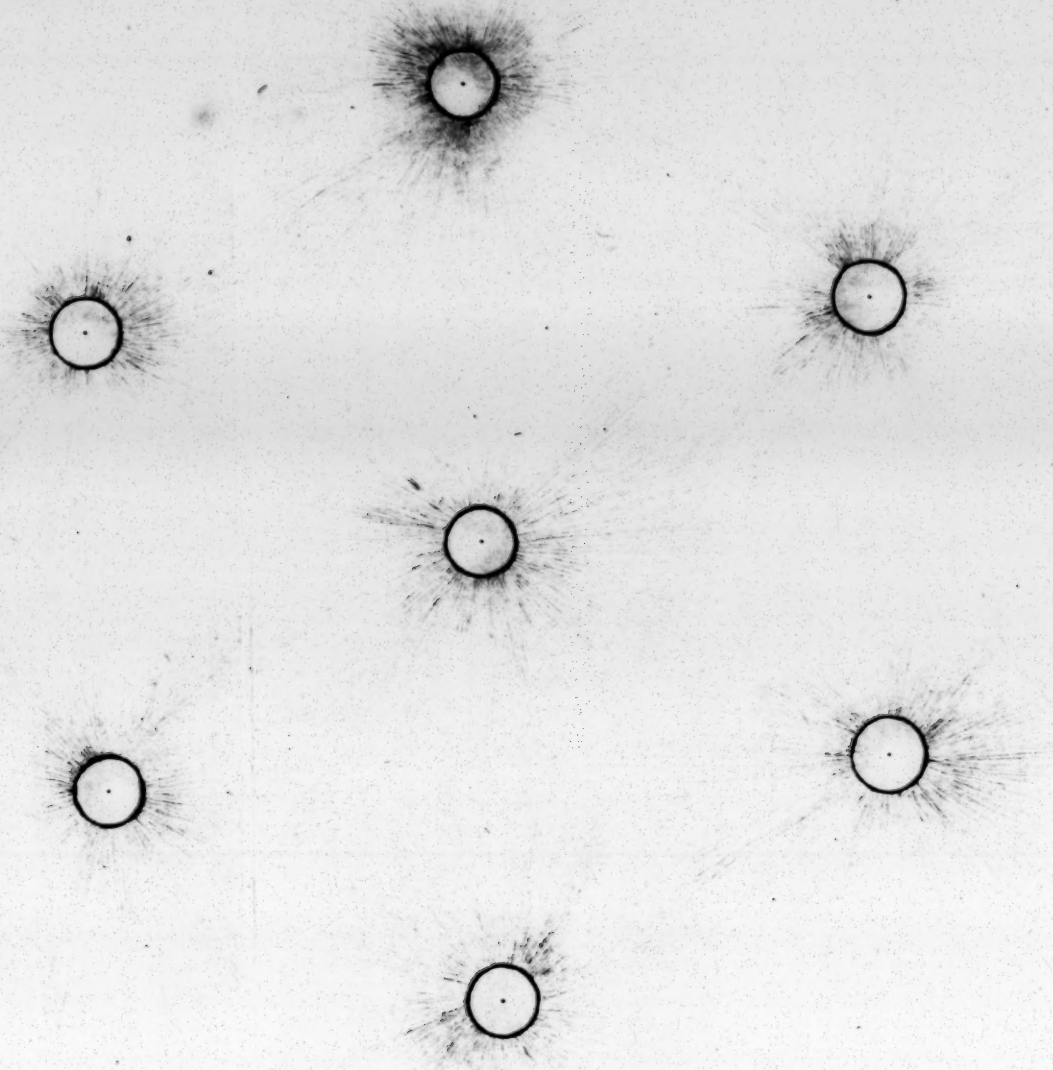
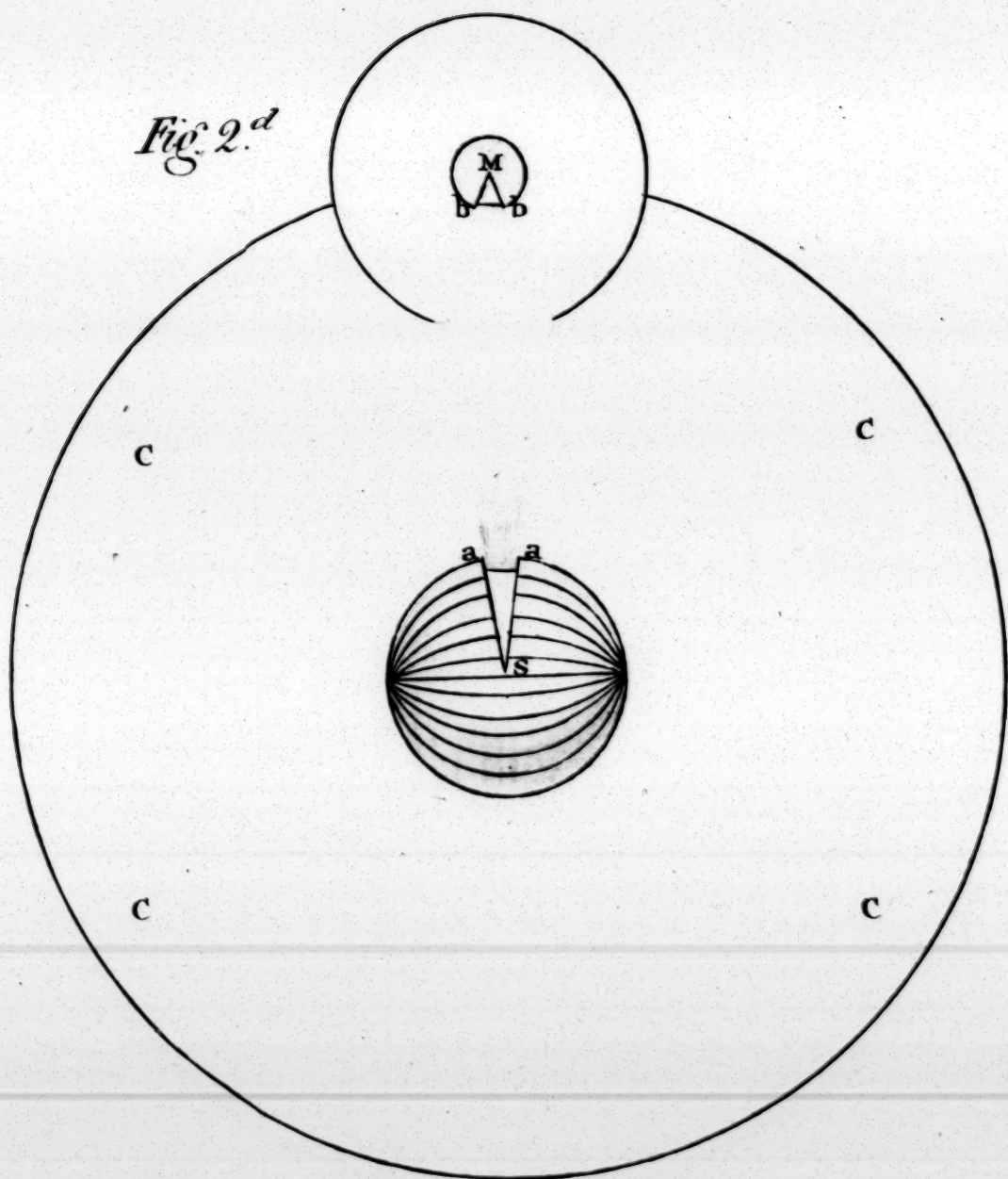
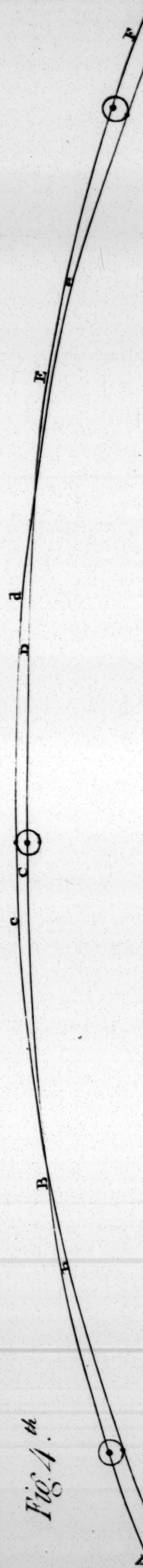
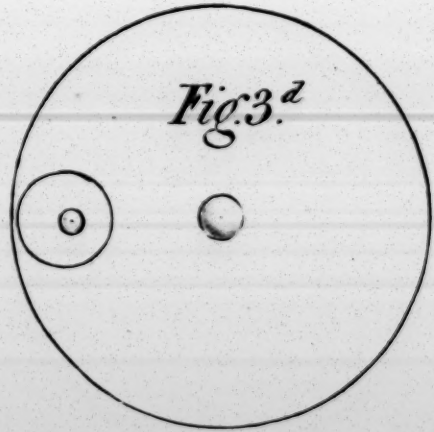
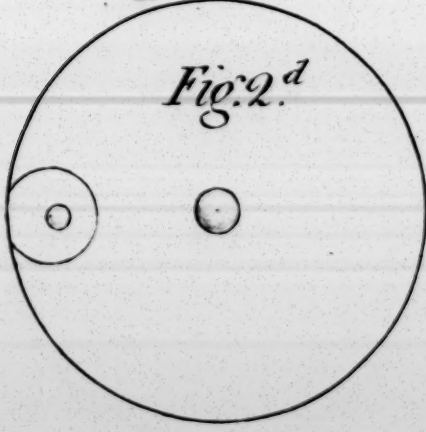
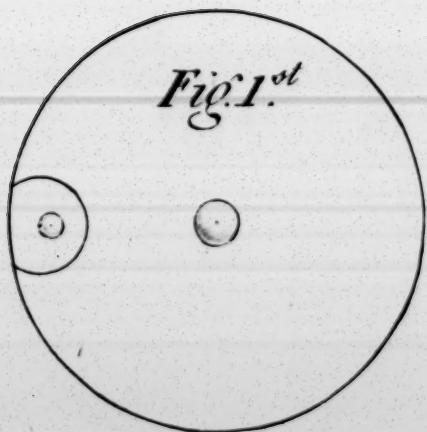
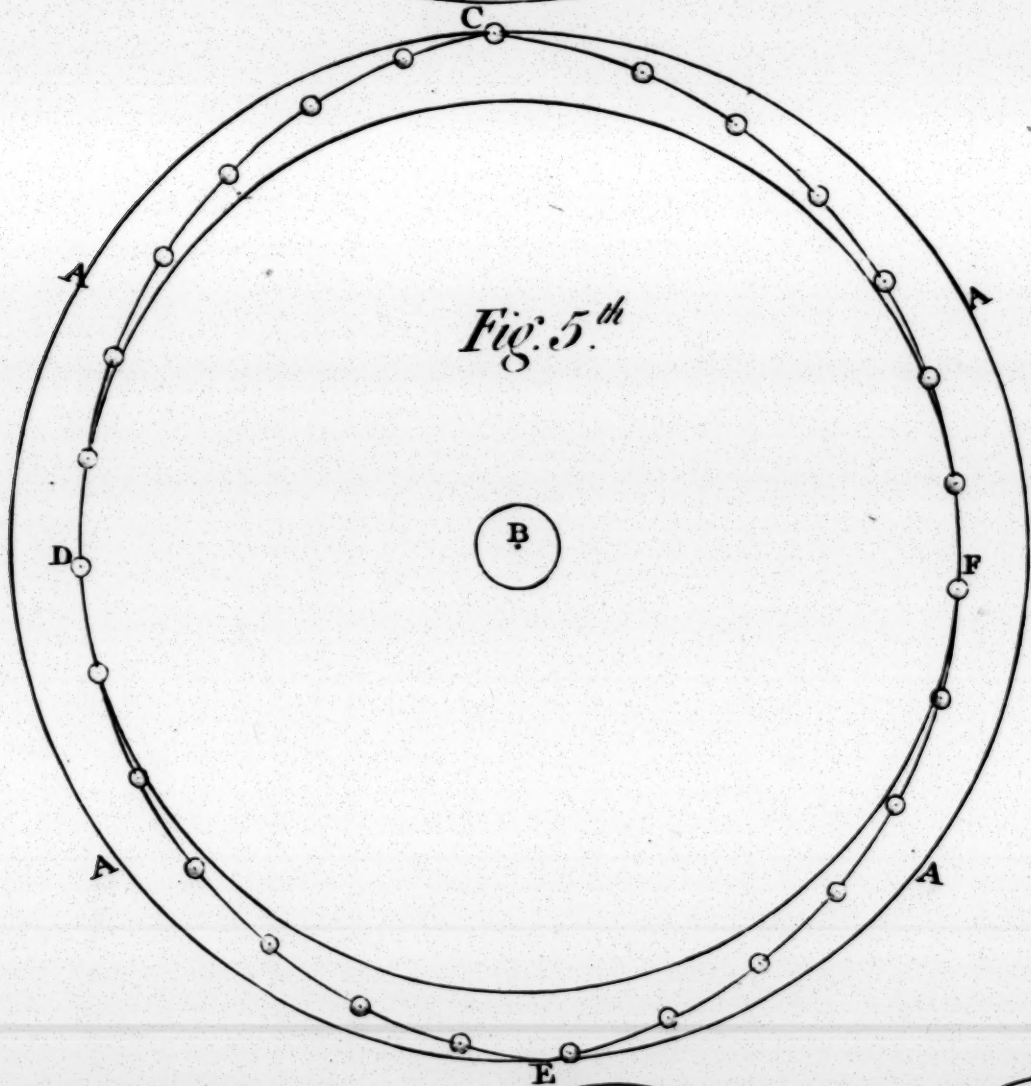
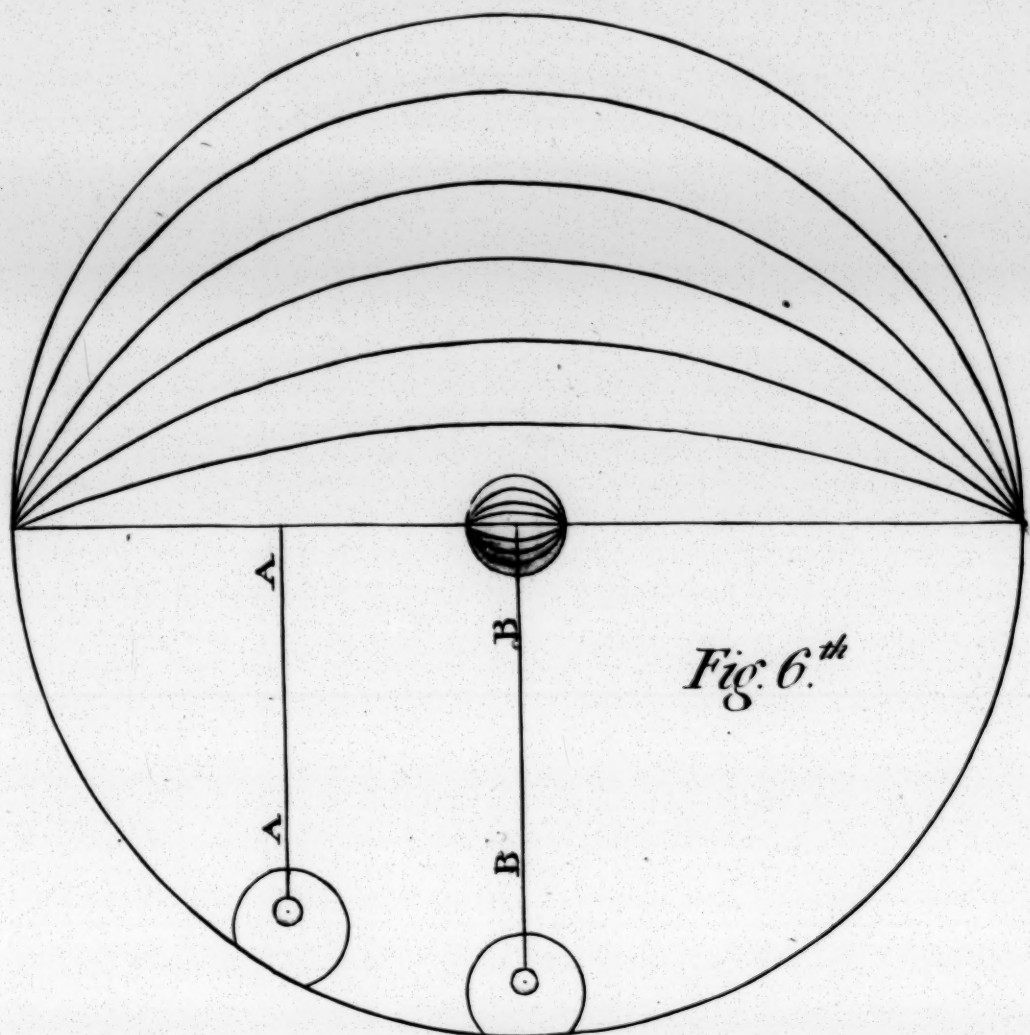


Fig. 2.^d







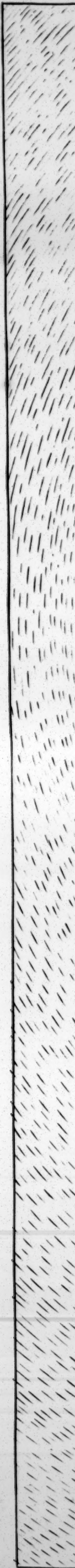


Plate A.

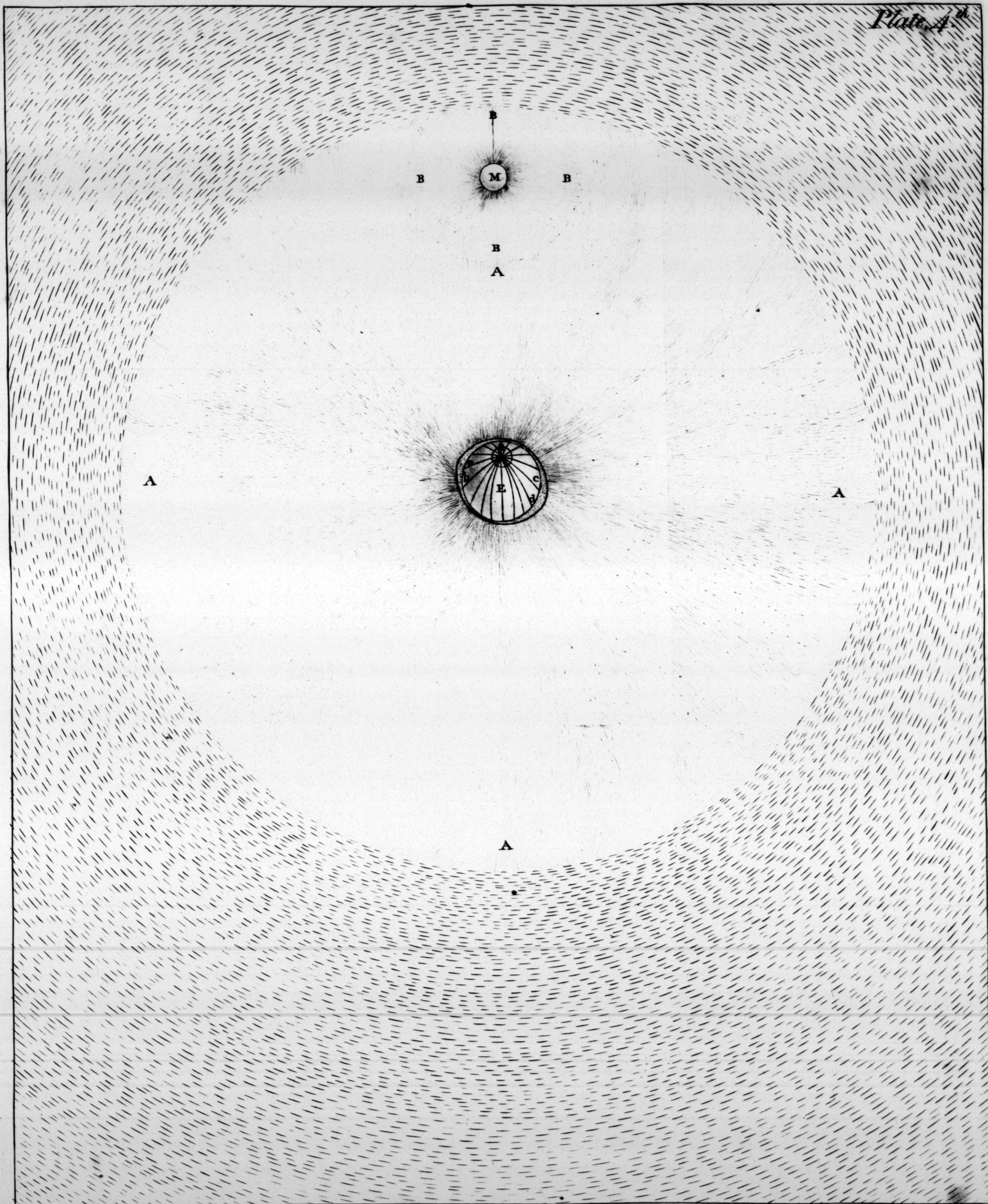
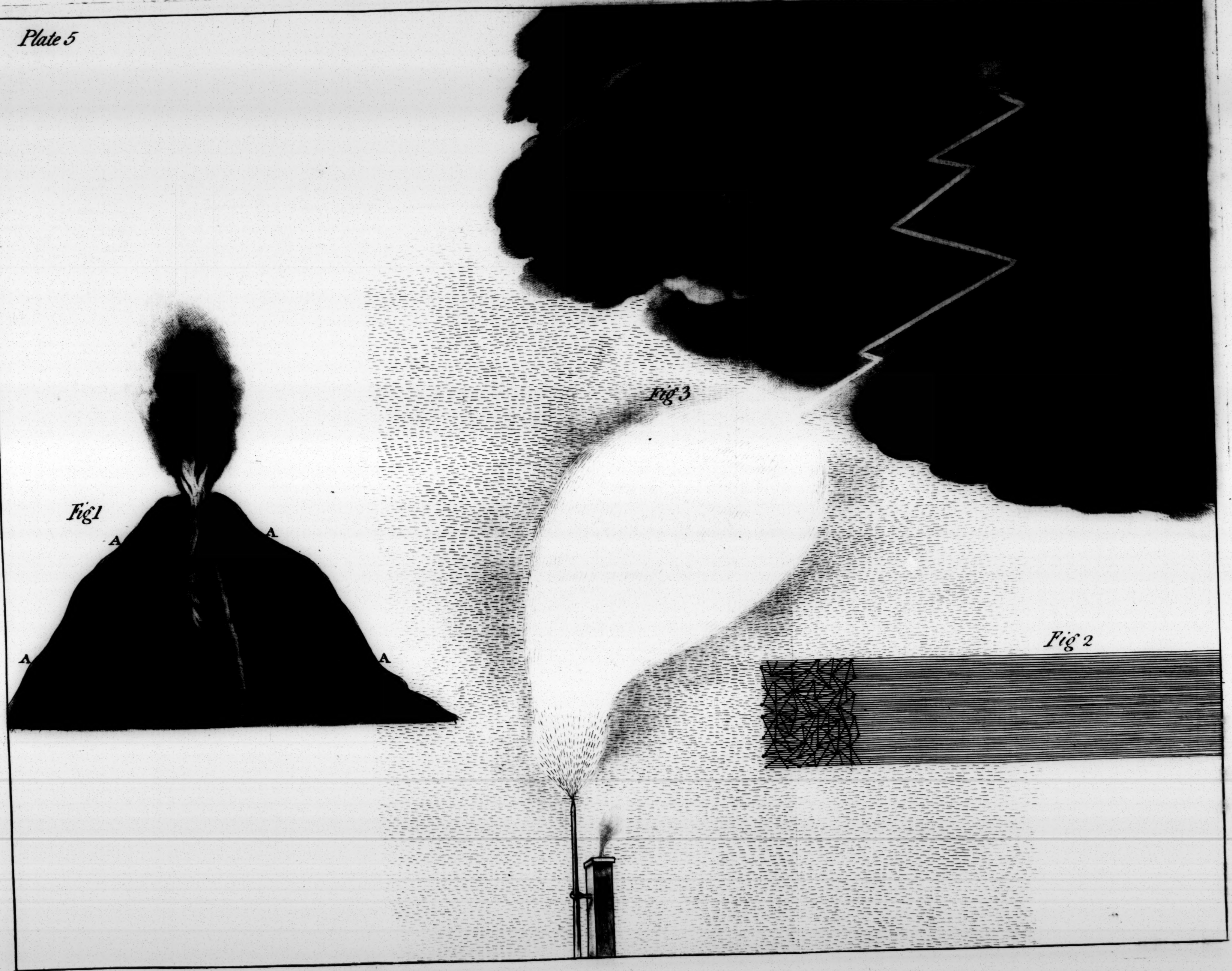


Plate 5



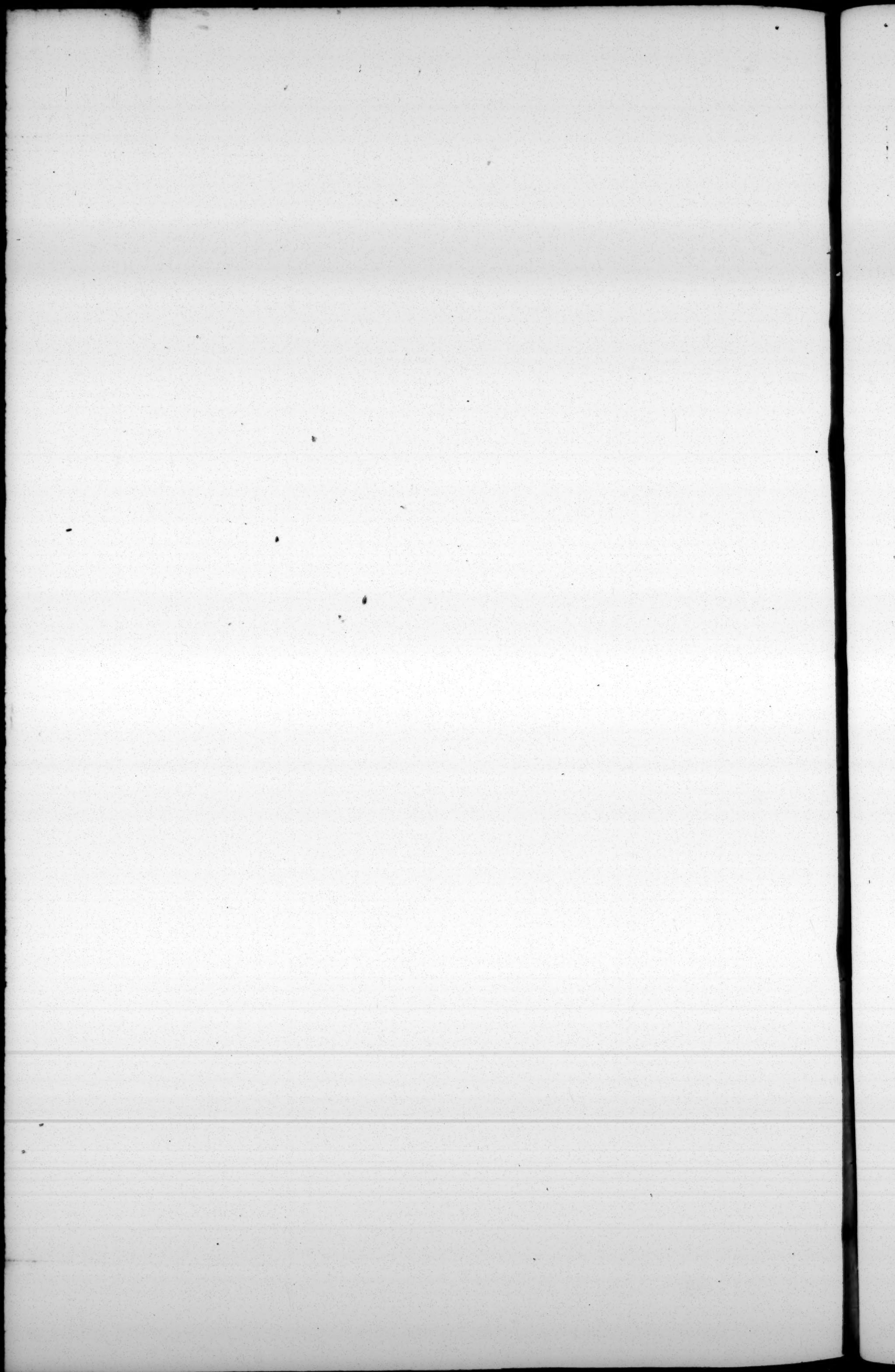


Fig. 1.

The diagram illustrates the internal structure of a ship's hull, showing the arrangement of various components and their relative positions. The hull is divided into three main sections labeled A, B, and C. Section A is the upper part, B is the middle part, and C is the lower part. A compass rose is located at the top right of the diagram.

A diagram of a sphere with center *E*. Points *A*, *B*, *C*, and *D* are marked on the sphere's surface. A shaded region extends from the sphere, bounded by a curved line and a dashed line.

